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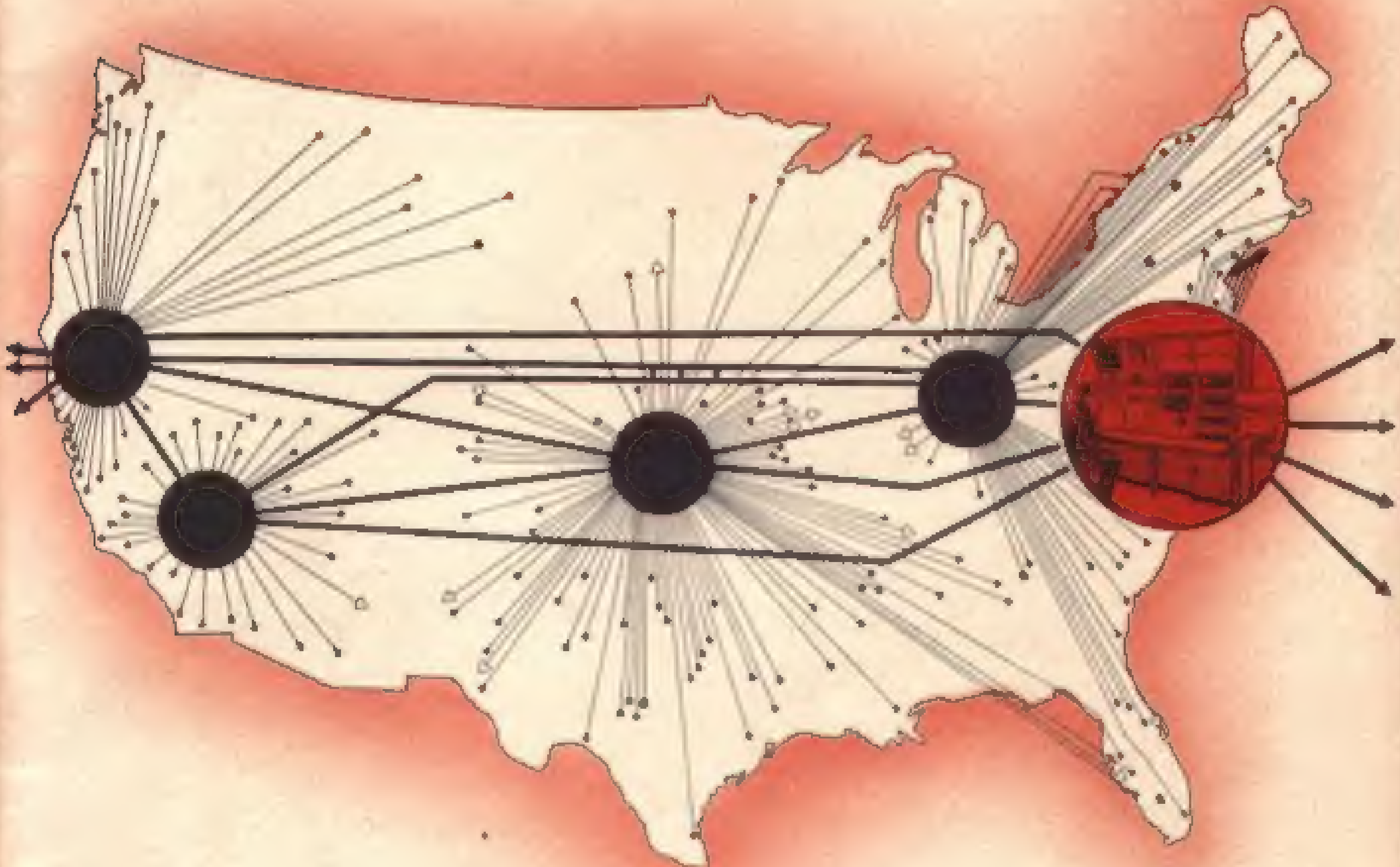

AUTODIN

COMMUNICATIONS SWITCHING ISSUE

THE WESTERN UNION TECHNICAL REVIEW

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WESTERN UNION

Technical Review

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F. R. Firth and T. J. O'Sullivan, Project Engineers, Telex Division, P & E Department

The Solid State Remote Control Unit and Polar Adapter

The Solid State Remote Control Unit 11272-A and its adjunct, Polar Adapter 11225-A, were designed to provide a universal remote control unit, adaptable to all subscriber requirements in Western Union's expanding U. S. Telex Network. Simplicity of maintenance, reliability and long life were the design goals for these units. Alone or with the Polar Adapter, the 11272-A Remote Control Unit can replace all existing remote control units, terminate all Telex subscribers, and work with any type of telegraph send/receive apparatus.

In Western Union's U. S. Telex Network, the remote control unit (RCU) is an integral part of the subscriber's outstation equipment. It initiates and disconnects calls and controls the subscriber's communications equipment.

Early Development of the RCU.

Until recently, five different types of RCU's were used in the U. S. Telex Network to meet various operating conditions. The AC/DC, N and NL Remote Control Units connected "local" subscribers to the network, while the ND and NDL Remote Control Units connected "long-distance" subscribers.

Each RCU must generate and recognize certain signalling criteria to establish connections between the subscriber and the Telex Network. These criteria are:

- Generation of a "request-to-dial" signal,
- Recognition of a "proceed-to-dial" signal,
- Generation of dial digits for call selection,
- Recognition of a "call-connected" signal,
- Generation of a "disconnect" signal,
- Recognition of a "call-disconnect" signal,
- In addition, the NL and NDL types provide a control for connecting the teleprinter to a local off-line circuit.

As the U. S. Telex Network grew, it became necessary to re-evaluate the remote control unit equipment. There were too many types of RCU's and all were designed using relay circuitry only. Western Union then designed an RCU having greater reliability and more sophisticated circuitry, using semi-conductors rather than relays.

The New RCU

Western Union recognized a two-fold problem in designing a universal RCU—the device had to be designed to handle make-break line signals but must also be adaptable for polar signals. The majority of Telex subscribers, termed "local" subscribers, are connected to Telex exchanges via make-break loops with a 60-milliampere current in the connected condition. "Long distance" subscribers, are connected to Telex exchanges via two polar legs. Consequently, the new RCU had to be capable of handling both types of subscriber.

The most satisfactory and economical approach to the problem was to design two units; a basic unit, Solid State Remote Control Unit 11272-A, for "local" subscribers; and a secondary unit, Polar Adapter 11225-A, to be used with the basic unit for "long-distance" subscribers. The basic unit contains circuitry for handling the RCU signalling criteria while the secondary unit coverts polar signals to make-break. Figure 1 shows the Solid

State Remote Control Unit and the Polar Adapter.

Solid State components were used wherever possible instead of relay circuitry. These components reduced size and weight and provided the advantage of inherent reliability.

There are two power supplies in Remote Control Unit 11272-A. One is used to drive the selector circuit only. The second drives all the other circuitry. Two transformers, mounted on the chassis, used in conjunction with rectifier diodes and filter capacitors (mounted on the two circuit cards) comprise the two power supplies.

Connectors mounted on the rear of the chassis provide terminations for the two wires from the Telex exchange, for the teleprinter and for power.

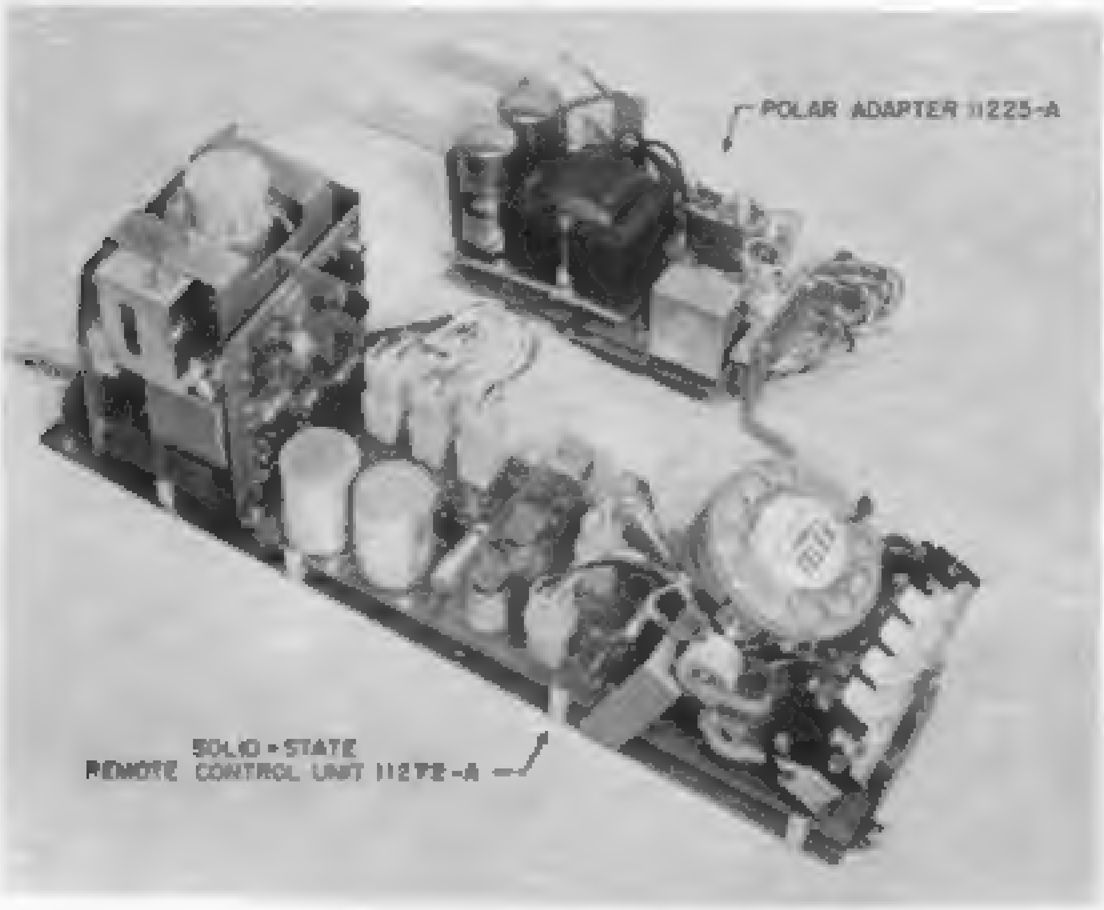

Figure 1. Solid State Remote Control Unit and Polar Adapter

Description of Equipment

Remote Control Unit 11272-A consists of three removable sub-assemblies mounted on a chassis. The sub-assemblies consist of two printed circuit cards and a dial-and-switch assembly. One printed circuit card is mounted vertically in an edge connector on the chassis. The second card, supported horizontally, is electrically connected to the chassis and to the dial-and-switch assembly by means of removable connectors. The dial-and-switch assembly, mounted on the front of the chassis, contains all the switches and indicator lights used to generate and indicate RCU switching criteria.

General Operation

Depressing the START switch generates a request to the exchange for a dial signal. The dial lamp is illuminated when the proceed-to-dial signal is received. The dial is then used to call the desired subscriber. The receipt of a call-connected signal is indicated by the connect light. Communication can then begin.

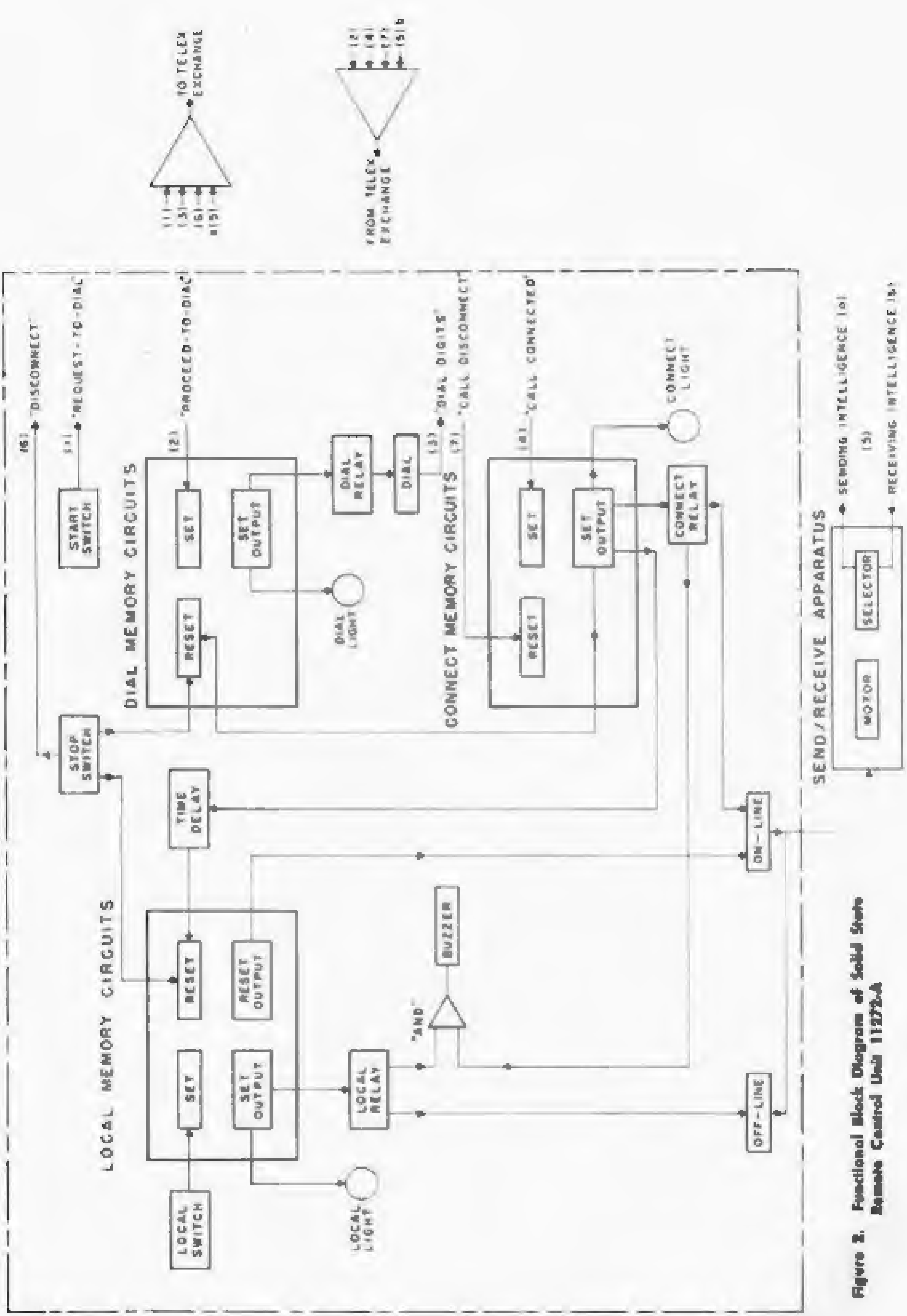

Figure 2. Functional Block Diagram of Solid State Remote Control Unit 11272-A

Depressing the STOP switch generates a disconnect signal. On receipt of a disconnect signal, the connect light is extinguished and the outstation returns to its idle condition.

Depressing the LOCAL switch while the outstation is idle, connects the teleprinter to a local circuit and lights the local lamp. If an incoming call is received while the teleprinter is switched to the local position for preparing off-line tape or hard copy, a buzzer mounted on the dial-and-switch assembly sounds an alarm. This warns the operator that the outstation can no longer be used off-line.

Storing Signalling Criteria

Semi-conductor memory circuits and three relays on the horizontally mounted circuit board respond to the switch operations and signals from the Telex exchange. The memory circuits essentially "store" the generated and received signalling criteria. This stored information determines whether the relays are operated or released and turns on the lamps on the dial-and-switch assembly. Accordingly, the relays switch the incoming line and the teleprinter selector to "on-line," "off-line," or "idle" circuits.

Selector and Motor Control

The vertically mounted circuit card contains semi-conductor circuitry used for controlling the motor and selector. A transistor amplifier circuit on this card converts a 60-ma current to 500-ma to drive the teleprinter selector magnet. A second transistor circuit on this card controls the operation and release of a motor-start relay mounted in the chassis. This circuit is actuated by the memory circuits on the horizontal circuit card.

Circuit Operation

Figure 2 is a functional block diagram of Solid State Remote Control Unit 11272-A. The signalling criteria, designated (1) through (7), in Figure 2 apply to Outgoing Calls, Incoming Calls, and the Local Position.

Outgoing Calls

Depressing the START switch generates a "request-to-dial" signal, designated as (1) on the chart in Figure 2. A "proceed-to-dial" signal, (2), is returned to the RCU from the exchange and is stored in the dial memory circuits. The memory output operates a dial relay which connects the dial to the outgoing line. The dial lamp lights, indicating that dialing can commence. Dialing generates selection dial digits, (3). Receipt of a "call-connected" signal, (4), from the exchange sets the connect memory circuits. This memory output operates a connect relay and connect lamp. It also resets the dial memory circuits. The connect relay turns on the teleprinter motor and places the selector "on-line" for two-way communication, (5).

After the message is completed, depressing the STOP switch generates a "disconnect" signal, (6) to the exchange. The exchange returns a "call-disconnect" signal, (7) which resets the connect memory circuits to return the position to idle.

Incoming Calls

When the outstation is idle and the exchange wants a connection for an incoming call, a "call-connected" signal, (4), from the exchange sets the connect memory circuits. The operation, (5), (6) and (7) is similar to that above.

Local Position

Depressing the LOCAL switch sets the local memory circuits. The set output of these circuits operates a local relay and illuminates the local lamp. The local relay turns on the printer motor and switches the selector to a "local" or "off-line" position for off-line use of the teleprinter. If an incoming call is received while the selector is in local position, the connect memory circuits (4) operate, actuating the reset cycle of the local circuits through the time delay. When both circuits are activated, the buzzer sounds. After the local circuits are reset, the buzzer stops; the teleprinter motor remains "on" via the connect relay; and the selector is "on-line" for two-way communication, (5). The remainder of the operation, (6) and (7), is similar to that above.

Polar Adapter

Designed for use with the Solid State Remote Control Unit 11272-A, the Polar Adapter 11225-A connects "long-distance" subscribers to the Telex network. The RCU 11272-A can operate only with the 60-ma loop of "local" subscribers. However, with the Polar Adapter as an adjunct, the RCU can operate with subscribers connected to Telex exchanges by means of polar signals.

The Polar Adapter is mounted on top of the 11272-A Remote Control Unit, as shown in Figure 3. When connected electrically, the two units make up a single polar remote control unit.

Figure 3. Model 32 KSR with Solid State R.C.U. and Polar Adapter (cover removed

Figure 4. Model 32 KSR with Solid State R.C.U. and Polar Adapter

Advantages

▲ Fewer Relay Contacts

Solid State Remote Control Unit 11272-A has fifty fewer relay contacts than the earlier RCU's. This was achieved by using diodes and germanium transistors, wherever feasible, to replace relay circuitry.

▲ Reduced Weight and Volume

The use of diodes and transistors in place of relays greatly reduced the weight and volume of the unit.

▲ Longer Life

"Worse case" procedures were applied in the design of this unit, which logically result in longer life expectancy and greater reliability.

▲ Ease of Trouble-Shooting

The transistors are used in saturation switch circuits.[1] This mode of design reduces the transistor to a switching logic element, i.e., it is either in the "ON," "1," or "SET" state or it is in the "OFF," "ZERO," or "RESET" state. This, in turn, makes it possible to check the state of each transistor with a simple voltmeter. The voltmeter reading clearly shows whether or not the transistor is in the correct state and eliminates the need of an oscilloscope.

▲ Simplified Maintenance

Maintenance for correcting a violation of the signalling criteria has been reduced to checking one of the three removable sub-assemblies. The circuits associated with each of the criteria have been unitized on the sub-assemblies. This type of packaging simplifies maintenance tests by restricting investigation to only the circuit components involved.

* * * *

References:

1. "Comparison of Saturated and Non-Saturated Switching Circuit Techniques," G. H. Goldstick, IRE Transactions On Electronic Computers, Vol. EC-9, No. 2, June 1960.
2. "Type 600 Automatic Four-Wire Switching System," K. M. Jockers, W.U. TECHNICAL REVIEW, July 1963.

Applications

The new remote control unit can replace many types of units now in use. Used alone, the Solid State Remote Control Unit 11272-A can replace the AC/DC, N, and NL Remote Control Units now working in the U.S. Telex Network. Used in conjunction with Polar Adapter 11225-A, the Remote Control Unit can replace the ND and NDL Remote Control Units.

Originally, both the Polar Adapter and the Remote Control Unit were designed without a separate cover, for mounting under the cover of a Model 32 Teleprinter, as shown in Figure 4. However, their initial success spurred interest in their application with other types of equipment used in Telex.

A cover was designed to enclose the two units, allowing their use with equipment other than the Model 32. Housed in this fashion, the versatility of the units was greatly extended. They now can be used with Type 19 ASR Sets, as well as with Model 28 and T-100 Teleprinters.

At present, they are used as a separate switching element in the New Orleans Type 600 Switching System [installed for the National Aeronautics and Space Administration (N.A.S.A.), in April 1963.]

The versatility of Remote Control Unit 11272-A with Polar Adapter 11225-A allows it to terminate any type of Telex subscriber. It can be used with any type of telecommunications intelligence send/receive unit operating at telegraph speeds.

Mr. E. R. Firth is an Engineer in the Telex Division of the Plant and Engineering Department. He is presently [illegible] computer interface for Western Union's Telex System and [illegible] signalling equipment for [illegible] Type 600 Telex Switching System.

He joined Western Union in 1959, when he was assigned to the Automation Applications Engineer. He assisted in the development of Plan [illegible] before being assigned to the Telex Division in 1960.

Mr. Firth received his degree in Mechanical Engineering from Stevens Institute of Technology in [illegible]. He is a member of I.E.E.E. and has several patents pending.

Mr. T. J. O'Sullivan has been a member of the Western Union's Telex Division since its organization in March 1960. He has been concerned with the applied engineering aspects of the TW56-WU Telex Concentrator and the tariff circuitry for the TW56 and TW39 Telex Systems. Prior to that, he assisted in the first Western Union Telex installation at New York City in 1958.

After joining Western Union in 1955, he was assigned to the Apparatus Engineer's Section. He assisted in the development of regenerative repeaters and small office reperforation equipment and apparatus associated with Reperforator Switching. He also assisted in the development of Switching Systems Plan 55, Plan 57 and Plan 38.

Mr. O'Sullivan received his B.E.E. degree from Manhattan College and is a member of the I.E.E.E. He has previously written an article on the TW56 Telex Concentrator for the Western Union TECHNICAL REVIEW.

B. E. Codd, Project Engineer, Patron Systems Div.—Plant and Engineering Dept.

Switching System—Plan 56-B

Switching System Plan 56-B is the successor to Switching System Plan 56-A a private telegraph communication system originally designed to meet the communications requirements of brokerage firms.[1] Subsequently Plan 56-A was applied to other industries.

Plan 56-B was designed to meet present day requirements for 100 wpm operating speed. Plan 56-A was limited to 75 words per minute. The maximum speed of the main telegraph unit of the Plan 56-A system, a composite typing reperforator and transmitter-distributor unit called the FRXD is 75 wpm. Plan 56-B has three different operating speeds, 60-, 75-, and 100 words per minute, and uses a typing reperforator and transmitter-distributor called the LRXD which has a manual selector for these different operating speeds. Plan 56-B also provides for sending to either 20 lines, (the same as Plan 56-A), or to 40 lines to accommodate the needs of larger customers.

Switching System Plan 56-B is a "store and forward" message switching system which automatically interchanges messages between stations on different circuits through a fully automatic switching center. The switching center receives messages in the form of punched paper tape and automatically transmits them to their destinations. Switching System Plan 56-B was first installed for Olin Mathieson Chemical Corporation with the switching center located in New York City.[2]

Switching Center Equipment

The switching center equipment is housed in rows of cabinets, as shown in Figure 1. A "switching aisle" between rows provides access to the cabinets for monitoring or supervisory purposes.

Messages from the outstations are received in Reperforator Switching Cabinets which terminate two incoming lines. Each Switching Cabinet has the necessary equipment to automatically direct the messages from the two lines to their destinations. Two LRXD units are mounted in each Switching Cabinet. Each unit is composed of a typing reperforator section and a transmitter-distributor section. Messages are received in the form of coded punched tape in the typing reperforator section, and are then sent from the transmitter-distributor section. A chute, located between the two sections of the unit, directs tape from the typing reperforator section into a tape

Figure 1   Plan 56-B Switching Center

accumulator bin for temporary storage until it can be transmitted. The tape reading head of the transmitter-distributor is mounted on a pivoted arm. This allows the transmitter to read the tape up to and including the last character punched. Thus, it eliminates a need for control equipment to provide a tape feed-out between messages.

The Send Circuit Cabinet contains relay banks and auxiliary equipment for a maximum of 40 outgoing circuits. Each outgoing circuit is terminated in one relay bank to which the Switching Cabinet transmitters are connected by means of their directing equipment. These relay banks keep the outgoing lines closed during idle periods. When a connection is made to a circuit, its relay bank provides a "busy" indication to all other switching position transmitters seeking the circuit.

Plan 56-B is a single storage system which requires no "cross office" reperforation equipment, as do some automatic switching systems. The switching equipment in Plan 56-B makes a direct connection to the outgoing line. However, "cross office" reperforation, within the switching center, can be accomplished with tape repeater cabinets which terminate outgoing lines. Special control functions can be performed by the tape repeater cabinets before the messages are repeated to the outgoing circuits. These cabinets are similar in appearance to the Reperforator Switching Cabinets. They use LRXD units, but have no directing equipment because each position always sends to the same circuit. Applications of Tape Repeater Cabinets will be men-

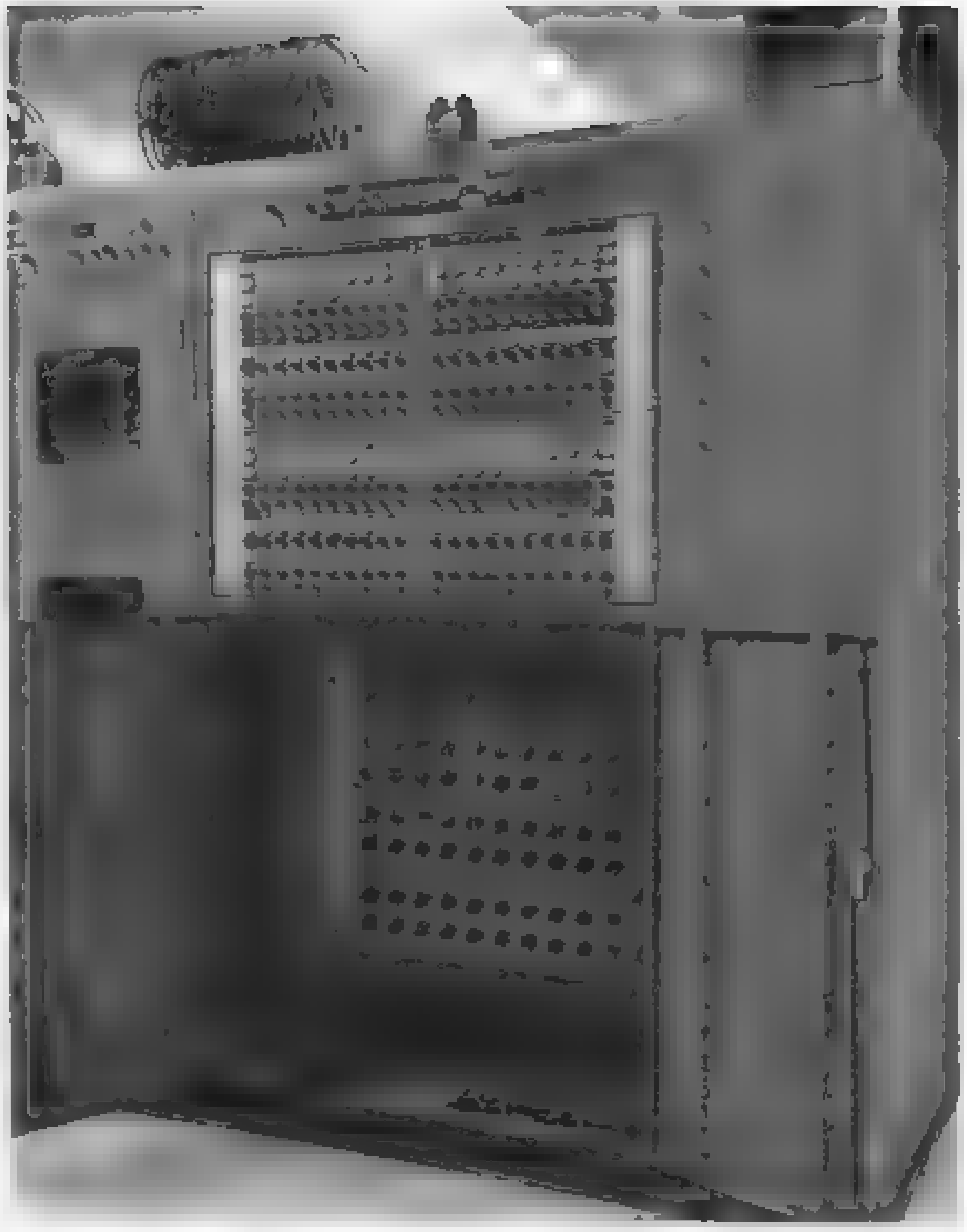

Figure 2. Routing Console

tioned under Special Features.

The Routing Console, shown in Figure 2, is a supervisory monitoring position which displays visually the traffic pattern at the switching center. Switches on the Routing Console are provided for "closing out" any outgoing line when an equipment failure or circuit failure occurs. A patching panel located in the lower portion of the console allows the supervisor to set up alternate routing, by means of a cord and plug, for any circuit which is closed out. Traffic destined for the closed out circuit will then be automatically re-routed to the circuit to which it has been patched. Traffic may also be re-routed to a local switching center position for disposition by the supervisor

Several alarm signals are provided on the Routing Console to give the supervisor a centralized indication of any trouble condition existing in the switching center. The supervisor's desk is located as close as possible to the Routing Console, so that its monitoring capabilities can be utilized readily

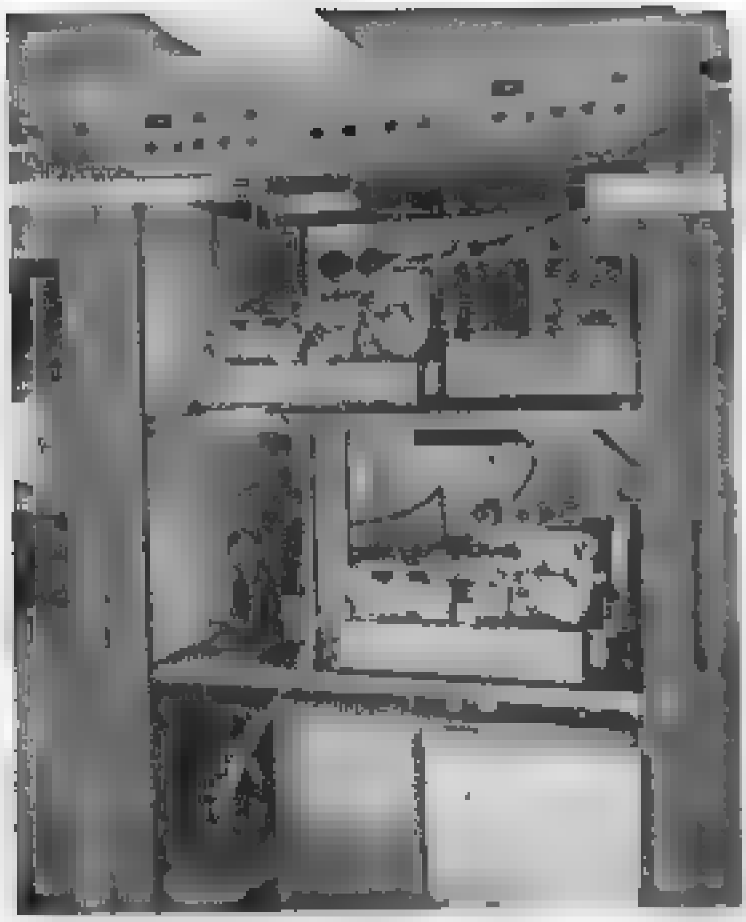

Figure 3 Two-Position Reperforator Switching Cabinet showing Two LRXD Units

As the destination address in the tape steps through the transmitter, directing equipment in the switching cabinet responds to the address and sets up the proper route to the destination, by operating a rotary stepping switch. This switch has moving or stepping contacts which can stop at any one of twenty separate points and connect the switching position transmitter with the outgoing line relay banks located in the Send Circuit Cabinet, shown in Figure 4.

Operation

Messages received, in tape form on an LRXD in a Reperforator Switching Cabinet, shown in Figure 3, feed from the reperforator into the transmitter which reads the address code of the designation circuit. The address code generally begins with the first character in the tape. When the system capacity is 20 circuits, the circuit address is a "one" character code. It may be any character of the alphabet except T, O, M, V, Z, or the message ending character, which is usually H. With a system having a 40-circuit capacity the circuit address is a "two" character code, the first of which is either A or U, and the second of which is any one of the twenty characters of the alphabet used for 20-circuit capacity

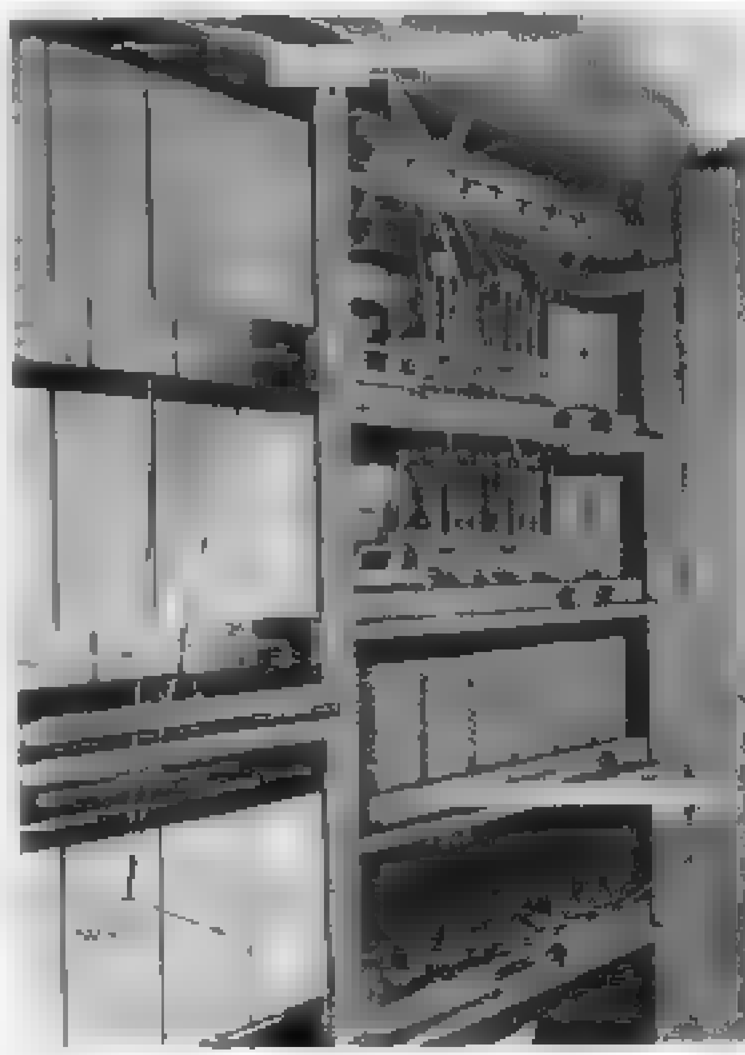

Figure 4 Send Circuit Cabinet

In a 20-circuit system, each switching position has one directing rotary switch providing access to all circuits. The one-character circuit address code selects the proper outgoing line by stepping the rotary switch to the point corresponding to the required line.

Each switching position of a forty-circuit system has two directing rotary switches which provide access to two separate groups of twenty lines each. As previously mentioned, a two-character address code is used. The first character selects the proper rotary switch and the second character steps the selected rotary switch to the required line point.

When a rotary switch has reached the proper point and the circuit is not busy, a common switching center "allotter" will allow that switching position to connect to the line. The allotter prevents more than one switching position from sending to a line at one time. Any other switching position, whose directing rotary switch stops at that point seeking a connection, will get a "busy" indication and will not be able to transmit. When the connected position has completed its message, the "busy" condition will be removed and the circuit will again become available to all switching positions.

If a switching position has a message for a busy circuit, this message must wait until the circuit becomes available. Tape may begin to accumulate between the reperforator and the transmitter of the LRXD. Therefore, tape accumulator bins have been provided with a capacity to store up to 150 feet of tape. This is equal to thirty minutes of receiving time at 100 words per minute and proportionately longer periods of time at lower operating speeds.

The switching center supervisor may dispose of waiting tape by manually directing the message to a standby or "spillover" switching position, from which the message will subsequently be automatically switched to its destination. The supervisor directs the message to "spillover" by throwing the SPILLOVER switch associated with the particular switching position. The "spillover" position has the same LRXD unit and directing equipment as a regular switching position and, therefore, can automatically process any message directed to it.

After the message which caused the tape to accumulate has been disposed of by the supervisor, the following messages, destined for idle circuits, will be switched to their destinations.

When a message having an invalid address code is received at a switching position, it will automatically be directed to a supervisory "intercept" position. This is a local position in the switching center consisting of a printer and or a printer perforator which copies the invalidly addressed messages. The supervisor may be able to determine the correct destination, by a visual inspection of the message at the intercept position. If the invalid address is due to "garbling," or interference, on the incoming line to the reperforator, and the garbling is such that the message is rendered unintelligible, the supervisor will request the outstation to resend the message.

A message with a valid address but garbled text, if detected, may be manually disconnected, lest the garbled text be sent to the destination. This is accomplished by pushing the DISCONNECT button on the Switching Cabinet. The supervisor must then send the garbled text to "intercept" by pushing the INTERCEPT button on the cabinet. The station which originated the garbled message is then requested to retransmit.

Message Format

Careful attention to preparation of the message format is required of the originating operators, as is true with all other automatic switching systems.

The directing equipment will only intercept messages with invalid addresses. If an originating operator addresses a message to the wrong circuit, the equipment cannot detect the error and the message will be switched. The operator who receives the message will then be responsible for re-routing it.

The message format requirements for Plan 56-B are: 1) Only single address messages or group call "broadcast" mes-

sages may be sent, since multiple address messages cannot be processed automatically by the system, 2) Messages must begin with the circuit address code and end with the message ending code. No other control characters are required during the message text. (To insure clear-out of the switching positions before each message, the message ending code may be inserted by the originating operator before the circuit address code, as well as at the end of the message.)

Other special functions such as "form feed out" or "horizontal tabulation" may be provided at the patron's option but are not required for the operation of the system.

Test Procedure

Test facilities on the Routing Console allow the supervisor to determine to which sending circuit a switching position transmitter is connected, and to indicate which other transmitters may be waiting to send to that particular line circuit. A test lamp and test push button are provided on the Routing Console for each transmitter and each sending line.

When a test button for a particular line is pushed, the following procedure occurs

1) If the line is busy,
   a) the test lamp for that line will glow brightly,
   b) the test lamp associated with the transmitter will glow brightly, and
   c) the test lamps associated with any other transmitters waiting to connect to that line will glow dimly.
2) If the line is idle,
   a) the test lamp for that line will glow dimly

Any transmitter position, can be tested by merely reversing the above procedure and pushing the test button associated with the particular transmitter.

1) If the transmitter is connected to a line,
   a) the transmitter test lamp and the test lamp for the line to which the transmitter is connected, will glow brightly,
   b) the test lamp associated with any other transmitter position waiting for a connection to that line, will glow dimly
2) If the transmitter is not connected to a line,
   a) the transmitter test lamp will glow dimly,
   b) the test lamp for the line to which it is waiting to connect, will glow brightly,
   c) the transmitter test lamp, associated with the position connected to that line, will glow brightly,
   d) the test lamp associated with any other transmitter position waiting for a connection to that line, will glow dimly.

The supervisor may choose to manually direct waiting messages to "spillover" or let them switch normally. A study of the traffic pattern shown by the test push buttons and test lamps will assist the supervisor in the disposition of these messages.

Special Features

The standard message switching equipment of Plan 56-B can be supplemented by optional equipment to provide the following features:

▲ On heavily loaded incoming circuits, message switching may be speeded up by alternately receiving messages from one circuit, on each of the two separate reperforator positions of a two-position Switching Cabinet, shown in Figure 2. This "flip-flop" receiving arrangement is particularly effective when the number of outgoing circuits is large and the traffic is evenly divided among them. For example, if a message, received in the upper position, is destined for a busy circuit it will have to wait; the next message will be received in the lower position and if it is destined for an idle circuit, it will be immediately switched

▲ A Message Waiting Indicator (MWI) shown in Figure 2, can be added to a Switching position or tape repeater position to avoid "tight tape" delays in transmission, when a transmitter operates at a higher speed than the reperforator and tends to run intermittently. The MWI counts the number of messages waiting for transmission and will prevent a transmitter from seizing a circuit until one complete message has been received. The transmitter will then run at full speed for the entire message and will not be interrupted by tight-tape delays.

MWI's are also generally used on switching positions receiving from stations which originate messages from keyboards. Since manual sending from a keyboard is usually slower than sending from a tape transmitter, delays due to tight-tape are likely to occur at the switching position in the center unless an MWI is provided to assure a complete message at the position before the transmitter starts sending.

▲ Automatic Message Numbering Machines can be installed in the Send Circuit Cabinet, shown in Figure 3, to transmit a channel identification code and a sequential number preceding each message. Numbering machines can normally be provided for a maximum of eighteen circuits.

▲ Group call or "broadcast" messages can be sent to a fixed group of circuits simultaneously by means of repeating relays mounted in the Send Circuit Cabinet. Broadcast transmission requires the use of one of the outgoing line relay banks and therefore, one less outbound circuit is available when this feature is provided. In a forty-circuit system a separate broadcast pattern can be established for each group of twenty circuits if one overall pattern is not required.

Broadcast transmission may cause delays in the switching center because a switching position with a broadcast message must connect to every circuit in the pattern and "busy" it out before the transmitter can start. If there is a long waiting period to connect to any circuit, no other position can send to the circuits already connected and busied out, and tape back-ups may develop at the switching positions.

▲ Automatic multi-channel equipment can be provided for destinations whose traffic volume is too great to be handled on one channel. The channels to one destination must be assigned consecutive circuit codes in the same group of twenty circuits. To make the most effective use of the multi-channel arrangement, messages should always be addressed to the first channel. Although multi-channelling heavily loaded destinations speeds messages transmission, it should be recognized that similar circuit facilities and outstation equipment are required for each channel and, therefore, similar charges apply for each channel.

▲ Tape repeaters can be used to send two types of messages to the same circuit: routine messages and priority messages. These two types of messages are terminated in the two positions of a tape repeater cabinet from which they are sent on a sharing basis to the same circuit. Normally this type of tape repeater is arranged so that all priority messages are sent before any routine messages are sent; however, any routine message in the process of transmission will not be interrupted to allow a priority message to be sent. Provision can also be made for a so-called "bust-in priority" operation in which the priority transmitter will immediately interrupt routine transmission and pre-empt the circuit as soon as a message arrives at the priority position. In both modes—priority and routine operation, two separate Model 28 receiving teleprinters are generally used at the destination, one for priority and one for routine messages.

▲ Changing of transmitting speeds can be accomplished in a Tape Repeater Cabinet when an outgoing circuit operates at a speed different from that of the switching position transmitters. The reperforator of the LRXD unit in the Tape Repeater Cabinet operates at the same speed as the switching position transmitters and the transmitter of the LRXD unit operates at the speed of the outgoing line. Speed changes on the LRXD are made

by means of separate three-speed manual selectors on the reperforator and transmitter

▲ The use of tape repeaters is also recommended on two-way operated single circuits to prevent switching delays and tape "back-ups" at the switching positions. Unless a tape repeater is used as a local termination in the center for messages destined for stations on the single circuit, the switching positions will be unable to make a connection any time inbound transmission is taking place. The tape repeater reperforator will receive all messages sent from the switching positions that are destined for the way circuit. The tape will be stored in the accumulator bin of the tape repeater until the single circuit becomes idle. The tape repeater transmitter will then send to the desired station or stations on the circuit. A switch is provided to give the tape repeater transmission priority on the circuit at the discretion of the switching center supervisor

▲ "Controlled" single and duplex way circuits, i.e., those on which sending from the individual stations is controlled from a central point, can be connected to the Plan 56-B Switching Center by means of tape repeaters. The tape repeaters contain line control equipment to regulate transmission from the way stations to the switching center. This is done by automatically generating "invitation to send" (ITS) characters. Each way station transmitter is controlled by a distinct ITS code.

Applications

Switching System Plan 56-B is an automatic switching system for general purpose use. The simplicity of the message format and the flexibility of the switching center equipment allow the use of a variety of outstation equipment depending on the requirements of individual patrons. Custom-designed outstation equipment is not required for this system.

The expansion capabilities inherent in the system allow a patron to install the system to meet present-day requirements and then add to it on a "building-block" basis in the future as communications requirements increase.

Acknowledgements

The author wishes to acknowledge the advice of Messrs. R. C. Ayers and H. E Amar, of the Patron Systems Engineer's office, in the preparation of this article.

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Mr Bartholomew E. Codd is a project Engineer in the office of the Patron Systems Engineer, Plant and Engineering Department He assisted in the circuit design and testing of Switching System Plan 56-B. Previously he was concerned with the development and testing of switching systems Plan 55, Plan 57, Plan 116, and EMATS

He joined Western Union in 1957 after receiving B E E degree from Manhattan College He is currently studying for a Master's degree in Industrial Management at the City College of New York

AUTODIN Expands Overseas

The AUTODIN program is being expanded to several points in England, Spain, Japan and Hawaii under a contract sponsored by the Electronics System Division of the Air Force System Commission.

Work has been underway for the Defense Communications Agency since June 18, 1963.

AUTODIN is a development of DATACOM which was designed by Western Union for the Department of Defense.

DATACOM was formerly known as Comlognet.

Typical Control Area in the AUTODIN Switching Centers

COMMUNICATIONS of the FUTURE

This particular issue of Western Union TECHNICAL REVIEW should prove to be of great interest to anyone who is either engaged in the business of providing communications services to others, or is a user of such services in large quantity and variety.

The term "switching systems" has many applications and connotations. Fifty years ago it meant some mechanical means of manually connecting one communications circuit with another. Today, it means not only that, but may also refer to a highly complex solid state switch gear capable of effecting circuit interconnections at extremely high speeds in many different arrangements for a multitude of purposes. For such purposes, the human eye and hand have become too slow and much too unreliable. The human brain has designed far beyond the body's physical capabilities.

The communications systems of tomorrow will continue to increase in complexity. The switching techniques which make such systems possible will set the speed and direction of this trend. It is therefore of great importance that close attention be given to the development of modern switching methods.

Vice President
Operating and Marketing Department

Falknor, F. B., Senior Project Engineer, DATACOM—Plant and Engineering Dept

AUTODIN Switching System Technical Control Facility

The AUTODIN Switching System consists of five large, solid-state interconnected switching centers each having its own group of 100 to 150 tributary outstations. These centers are located at Andrew AFB southeast of Washington, D. C.; Gentile AFS near Dayton, Ohio. Tinker AFB-Midwest City, Oklahoma, McClellan AFB-Sacramento, California, and Norton AFB-San Bernardino, California. All centers, except Tinker, have a capacity of 50 lines in the message switching unit and 50 lines in the circuit switching unit. Tinker has a capability of 100 lines in the message switching unit and 50 lines in the circuit switching unit.

The outstation equipment presently tied into the system is comprised of Compound Terminal outstations (CT) having a transmission rate of 150 bauds, High Speed Card-Teletype outstations (HS-CT) having a rate of 1200 bauds and Magnetic Tape outstations (MT)—2400 bauds. Other Military Teletype Network (OMTN) interconnections are also provided. These have transmission rates of 100, 75, or 65 words per minute. The trunks on the message switching unit are operated at the rate of 2400 bauds and those of the circuit switching unit are operated at the rate of the connected outstations. The information on the lines is transmitted in an 84-character record consisting of framing, control, block parity and 80 data characters. The character code is a modified Field Data code. The bit rates are equal to 75 x 2^N Where N is a positive whole integer

Every tributary line, with the exception of the center supervisor, and every trunk, except the interchange trunks between the message switching unit and the circuit switching unit, are link-encrypted by a bit encryption device requiring external clocking. This requires an encryption device at each end of a tributary line or trunk. The clock is of the stability to keep the cryptographic devices in step for one hour, on loss of the connecting link between them, at the highest rate (4800 bauds).

Circuit Configuration

Figure 1 shows the layout of the technical facilities for a 2400 baud trunk or tributary. The signaling scheme, used on both the bit or line clock and the data or information lines, is a polar 6v 10ma signal. The transmitting end is a solid state ± 12v polar device, with a 600 ohms internal impedance. The line is always terminated in 600 ohms at a receiver to maintain the correct signal levels. The receive bit clock is a 2400 cycle square wave with the negative cross-over in the middle of the data bit. This signal is derived from a double-transition synchronizing adapter (SYN-1). The send bit clock is similar to the receive bit clock but is generated by a single-transistion synchronizing adapter (SYN-2) on circuit switching lines or a simple driver on message switching lines. The synchronizer is used on a circuit switching send line because of the different phases the data bits assume depending on the connected receive line. A simple driver from the mas-

Editorial Note. This is the first of a series of articles on AUTODIN

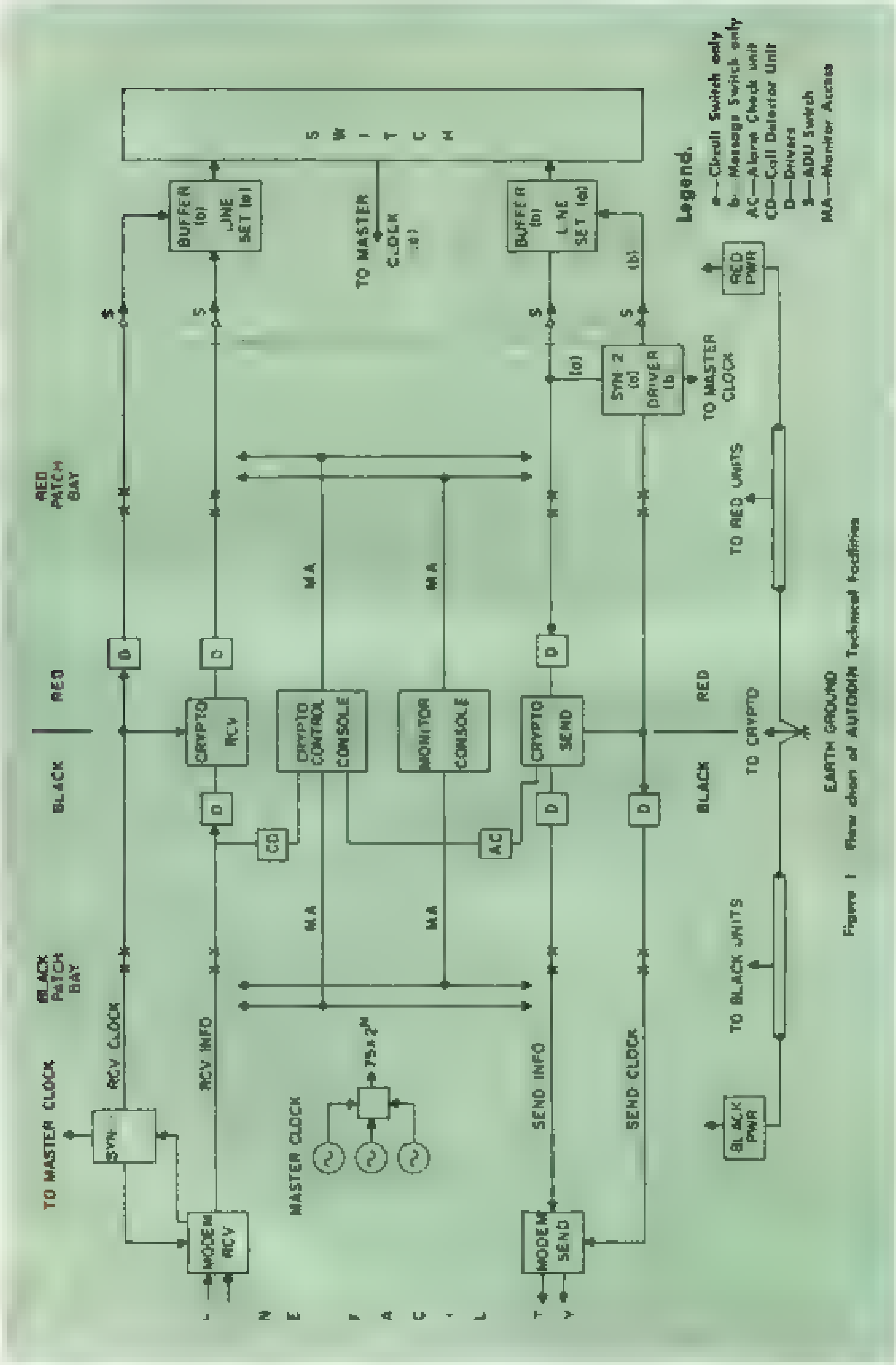

Figure 1 Flow chart of AUTODIN Technical Facilities

ter clock suffices on a message switching send line because it determines the phase and rate of the line.

At each patch bay the data circuit and the line clock circuit pass thru the same jack set. With this arrangement plus the adopted signal philosophy, back-to-back testing or equipment substitution can be made at all points in the circuit.

The circuits were designed with the electrical and physical separation between the decrypted (Red) and encrypted (Black) areas as a prime objective. Shielded cable was used for all data and clock paths. A separate battery was provided in each area. One of the functions of the drivers, clustered around the crypto units, is to provide electrical separation of the two areas as well as signal level conversion. A common ground, provided in each area is connected to the earth ground at the crypto at only one point.

Synchronizing Adapters

Figure 2 shows a Receive Synchronizer rack with 50 double-transition digital synchronizers (SYN-1) mounted in it.[1] The SYN-1 looks at a stream of data bits and derives a square wave with the negative cross-overs in the middle of the data bits. Theoretically, if the line facility could pass signals with a total distortion of 49 percent, the SYN-1 would still develop a bit clock with correct phase relationship. A clock is also available from this device for timing a synchronous modem such as the type used on a 2400-baud circuit.

Figure 3 shows a rack of 50 send synchronizers (SYN-2) at the bottom, plus drivers for 50 message switch send lines at the top. The SYN-2 is a single transition digital device that counts over to ½ of the bit and develops a clock. The signals, that the SYN-2 sees, are always regenerated but assume different phase positions.

The time base provided to the SYN-2 and -1 adapters by the Master Clock is 128 times the bit rate which is 307.7 kc for a 2400-baud circuit. The timing to the drivers for the message switching unit is at the bit rate. The time base to each

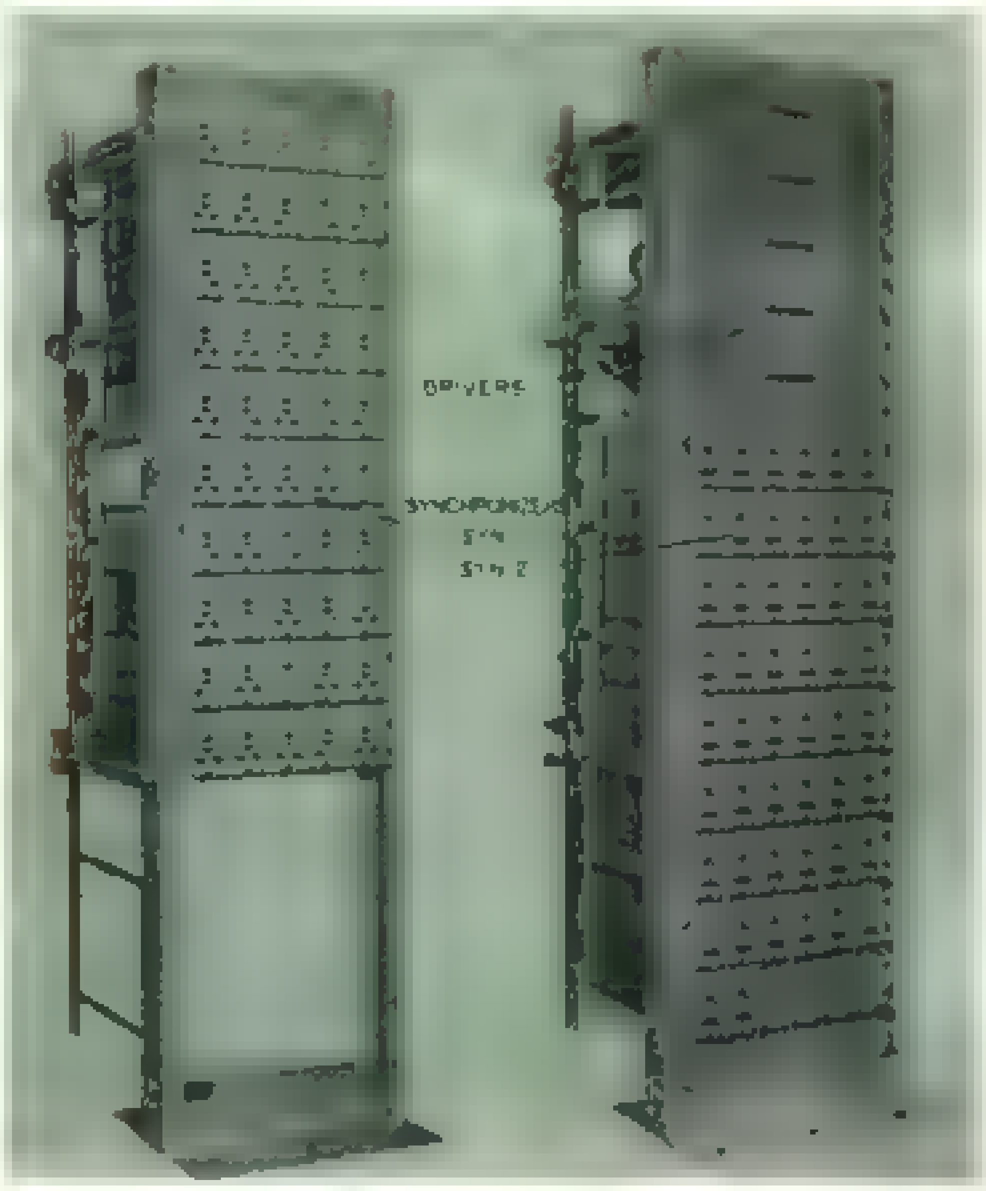

Figure 2. Rec SYN

Figure 3. Send SYN

courtesy of Stelma, Inc

synchronizer and driver can be changed by the movement of a simple wire strap. All time bases from 75 cycles to 614.4 kc are distributed to the appropriate units.

Master Clock

The heart of an AUTODIN Center is the Master Clock, shown in Figure 4. The Master Clock provides the time bases for all devices in the facilities area and also the buffer units into and out of the message switching unit plus the basic timing for the circuit switching unit. The Master Clock was designed for reliability, stability, and continuous duty even with internal failures. A large amount of redundency is designed into the Master Clock. If the Master Clock experiences a complete failure, the center would stop.

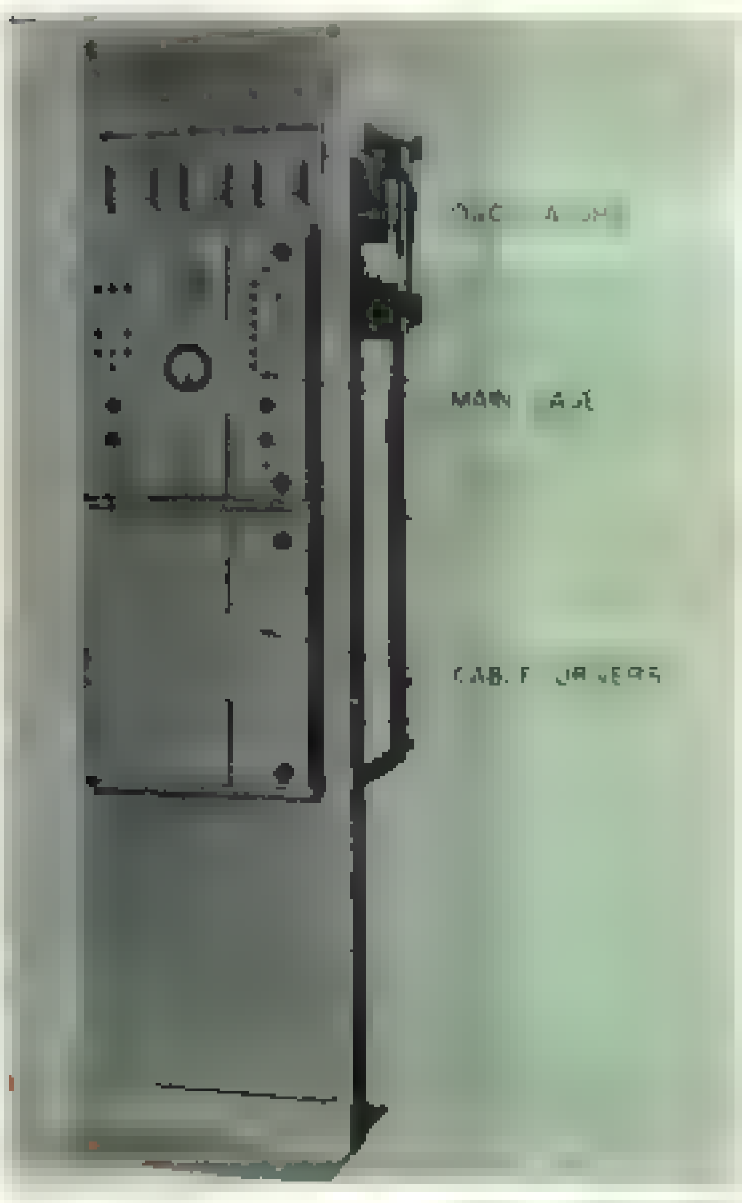

Figure 4. Master Clock

The basic timing is derived from one of three crystal oscillators at a frequency of 1.2288 mc. The crystal is temperature-controlled and compensated for aging to hold a long term stability of 5 parts in 10^9 per week. The three oscillators are constantly compared with each other so that if the one, which compares unfavorably with the other two, is driving the system, it is retired from service and the oscillator designated as the fallback takes over its duties. This switch is hardly noticed since it occurs at the megacycle level. The three oscillators are mounted in the second shelf of the equipment in Figure 4.

The output of the driving oscillator is counted down thru three 14 stage count-down chains in the main cage section to obtain the useful rates. Each level of each chain is majority-gated in such a manner that a single stage failure can be tolerated without interrupting a complete chain. This chain is restored starting with the next stage after the failed one.

The output from the three chains are majority-gated to buffers called "cable drivers." These drivers can tolerate a single failure on any one of three inputs. A cable driver is a group of three drivers that are ORed together at their output so that if anyone of the three fail, a useable output is still available. A required time base is distributed by more than one cable driver so that the distribution line can be shorted or open-circuited and still not affect the whole center. The cable drivers are mounted in the bottom cage.

The main cage, which contains the count down chains, has controls on its front door. These can be used in conjunction with switches mounted on individual cards, to completely check the failure detection circuits. A periodic check is made of the alarm circuits to guarantee their reliability.

One central Master Clock is chosen as the system's time standard. A test instrument, called a clock comparator, mounted in the black patch bay, uses a time base from the master clock and compares this with the data bits on a trunk or tributary line. In this manner, the oscillator frequency, at the remote center or outstation, can be determined in relation to the standard. Each center is responsible for its own complement of outstations. The

top shelf of the Master Clock provides 5 OMTN teletype time bases.

Monitor and Crypto Control Console

The Monitor Console and Crypto Control Console, shown in Figure 5, was built at Western Union's Chattanooga Works. The Monitor Console, shown on the left is the central display of all alarms and on-line bias indicators. It contains a push-button selection of a circuit in either the Red or Black area, as shown in Figure 1. These are used to monitor the selected circuit with various pieces of test equipment such as an oscilloscope, a bias and distortion analyzer, a pattern generator and a character reader. The character reader is a device that "frames" on the idle line pattern, present on the circuit, in the absence of data and is then capable of reading certain control and co-ordination characters and making a constant character parity check.

This console can be used to contact the outstations by teleprinter, thus bypassing the synchronous equipment and crypto. This means of communication can be used for special functions or in case of certain equipment failures to help restore service on the line. A telephone provides voice communication between centers and to certain military offices.

On the right, in Figure 5, is shown the Crypto Control Console. This unit has up to 300 crypto displays and controls (i.e. one per line) for establishing bit synchronism between crypto units on all trunks or tributary lines. These controls work in conjunction with two semi-automatic devices, a call detector on the receive line and an alarm check on the send line. The call-detector prepares the receive unit for bit synchronism on detection of a call generated at the opposite end of the circuit. The alarm check prepares the send unit for bit synchronism which sends a call to the call-detector at the remote end. Bit synchronism can be established on a circuit by depressing two control buttons. However, on a duplex circuit an operator must be present at the other end of the circuit. Means are provided for master synchronizing of the crypto or for group synchronizing for fast

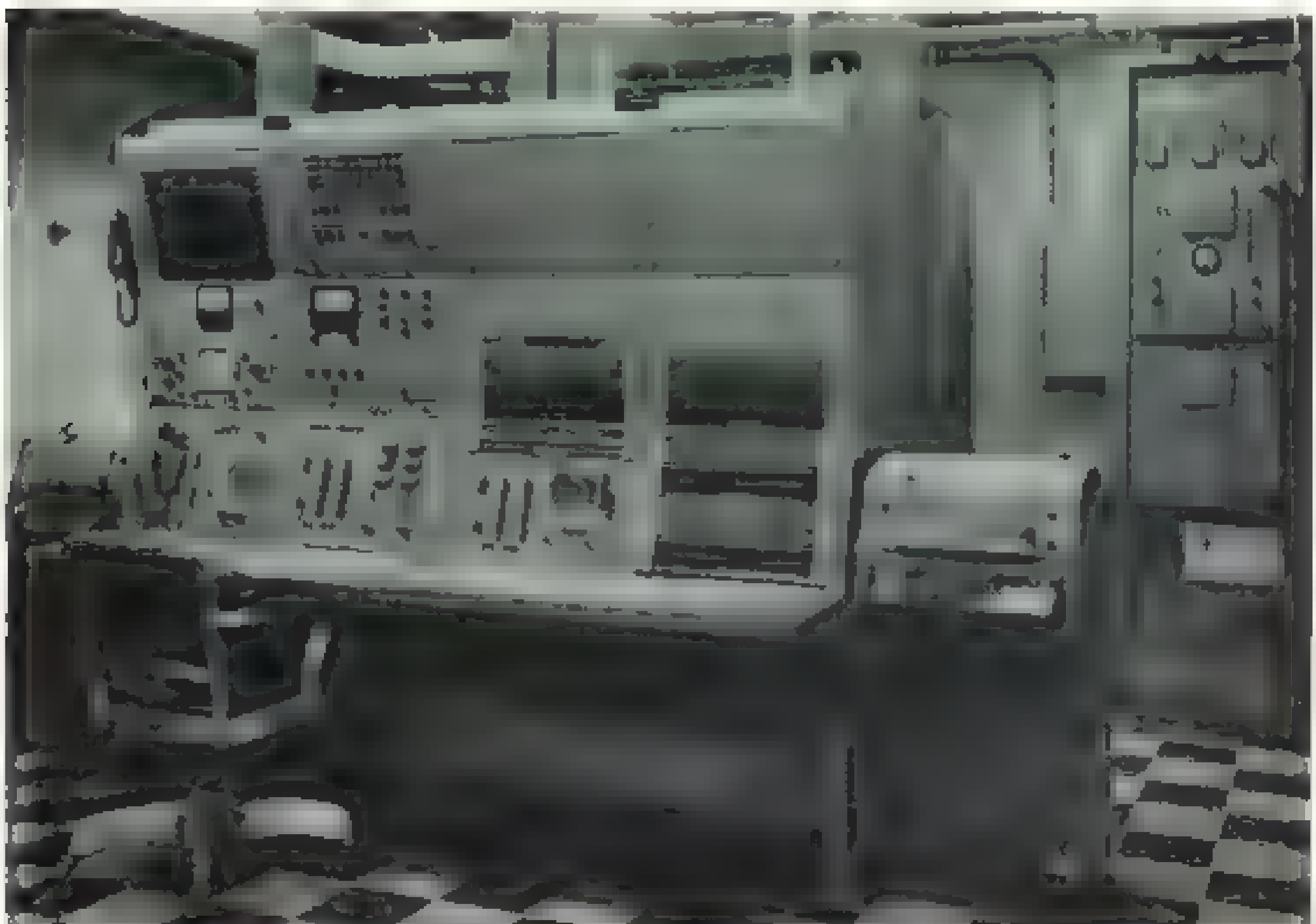

Figure 5 Monitor Console and Crypto Console

recovery from catastrophic troubles such as power failure.

The crypto console has a push button line selector and a character reader, similar to those in the monitor console. These units are used to determine if bit set was obtained with the remote units by detection of the idle pattern. As in the monitor console all synchronous equipment can be bypassed to talk to the remote stations by teleprinter in the event of extraordinary problems, concerning the crypto units at either end of the circuit

ADU Switch

At point S, in Figure 1, a switch is being added to move circuits from the input of one section of the message switching unit to another. The line terminating section of the message switching unit is broken into three or five separate sections called Accumulation and Distribution Units (ADU). If one of these ADUs fails, then the circuits which were terminated in that ADU can be reterminated in the ADU which is designated as a spare or is handling the lowest priority traffic. This transfer is accomplished by operation of a switch which affects the transfer without loss of bit set on the circuits.

Potential of AUTODIN

The AUTODIN Technical Facility was designed to provide maximum support with ease of operation to the switching units with a minimum amount of equipment. Manual, semi-automatic and automatic functions were provided. The choice from these three was determined by three factors—the rapidity, importance, and complexity of the function.

In future systems where some of the tasks to be performed in the facilities area become more complex, all traffic handling functions, presently performed, could be transferred to a central traffic control position associated with the switching unit.

The technical facilities for the AUTODIN System were designed to provide support to the switching centers in the communication circuits area. The technical facilities are responsible for monitoring and maintaining the signal levels between the line facilities and the input to the switching unit, establishing "crypto bit" set i.e. synchronism, on the circuits, restoring service on certain equipment failures and providing manual alternate routing. This area is under the operation and supervision of military personnel with only one man required per shift

* * * *

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MR. FRANK B. FALKNOR has been assigned to the DATACOM Program since 1960 and was responsible for the development of the DATACOM Technical Control facility.

Prior to the DATACOM project, he contributed to the development of Plan 55 and Plan 57

Mr. Falknor received his B.E.E. degree in 1954 from the School of Electrical Engineering at Cornell University.

THE 1963 D'HUMY MEDALIST

B. L. Kline

"For his development of new concepts of electrosensitive recording phenomena and for the embodiment of the results of his research in facsimile recording papers."

A copy of the Certificate of the Award presented to Mr. B. L. Kline appears on the opposite page. It was printed on TELEDELTOS...

The F. E. d'HUMY AWARD

PRESENTED TO

B. L. Kline

by

The Western Union Telegraph Company

"For his development of new concepts of electrosensitive recording phenomena, and for the embodiment of the results of his research in facsimile recording papers."

PRESIDENT

New York, September 25, 1963

1963 d'Humy Award to B. L. Kline

For his development of new concepts of electrosensitive recording phenomena and for the embodiment of the results of his research in facsimile recording papers and in the quality control of many materials to insure maximum communications efficiency."

Mr B. L. Kline, physical and chemical engineer in the Plant and Engineering Department, was awarded the 1963 d'Humy Medal for his "significant contribution to the telegraph art."

Past awards have been given for advances in the state of the telegraph art which were largely electronic or electromechanical in nature. This ninth d'Humy Award is given for advances due to research and development in the chemical field

Of Mr. Kline's many contributions to communications progress, the most important was his rôle in the development of the various types of electrosensitive TELEDELTOS paper—which are so important in modern facsimile telegraphy More than 50 million telegrams are received on TELEDELTOS, annually, on Western Union's automatic Desk-Fax machines.

In modestly accepting the d'Humy Award from President Walter P. Marshall at ceremonies held in Mr. Kline's honor—at Western Union headquarters, the medalist paid tribute to the hard work and constructive ideas contributed by members of his staff Mr. Kline heads the physical and chemical division of the Plant and Engineering Department.

During his career at Western Union, Mr. Kline has done important research and development work in inks, lacquers, resins, wood preservatives, rust-proofing, corrosion, wax compositions and detergents. He is best known, however, for his work on electrochemically sensitive coatings for facsimile recording papers. He has had more than 25 patents issued in that field and is regarded as one of the world's leading authorities on electrosensitive recording papers.

Previous d'Humy Awards

1962 William D. Buckingham	1958 W Dail Cannon
1961 Robert Steeneck	1957 J. Edwin Boughtwood
1960 Garvice H. Ridings	1957 F Beaumont Bramhall
1959 Harold F. Wilder	1956 William B. Blanton

K. M. Jockers—Senior Project Engineer, TELEX Division-P & E Department

Traffic Evaluation For Western Union Telex Network

Part I

The Western Union Telex Circuit Switching Network is a nation-wide network in which subscribers can establish a connection to one another for Teleprinter communications. A continuous analysis of the traffic must be made to ensure the proper operation of the network. Special evaluation equipment is used to report changes in the traffic pattern so that exchanges can be planned to meet these requirements and to predict future needs as the network expands. This article is written in conformity with industry practices with respect to service designations—a 1% designation means that a call has a 1% chance of finding a "busy" condition and a 99% chance of immediate completion.

Western Union Telex is a nation-wide circuit switching system for digital communications in which thousands of subscribers can be connected to one another in a few seconds through various combinations of switching stages and trunk sections. In some instances, these combinations are arranged directly by dial digits. In other cases, they are arranged by common control equipment which utilizes dial digits. The number of switch stages, trunk sections and common control units, provided to maintain an acceptable and economical service is determined by a continuous analysis of traffic.

Various considerations must be taken into account in a traffic analysis of a Telex network. While the network shown in Figure 1, encompasses all aspects involved in an analysis of our present Western Union Telex Network, it eliminates the complications of a large complex network. This illustration will serve to explain the principles involved in traffic evaluation and some simplified calculations are added to prove them.

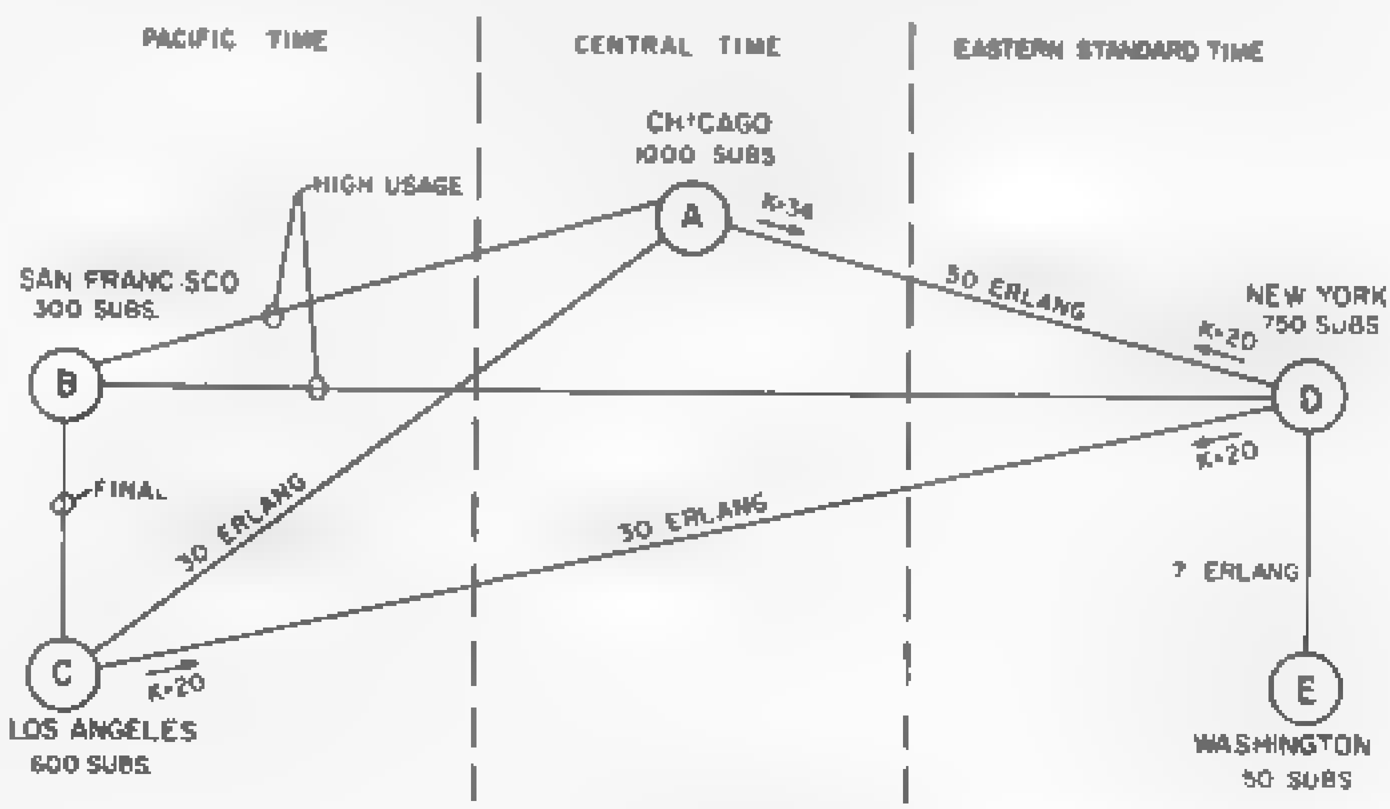

Figure 1 Simplified Telex Network

Trunk Analysis

The principal part of any circuit switching network is the trunks that interconnect the various exchanges. The quantity and type of trunks (direction of seizure) to be provided economically between exchanges depends upon the following

- Busy Hour
- Probability
- Grade of Service
- Accessibility
- Direction of Seizure
- Automatic Alternate Routing
- High Usage and Final Trunk Group

Busy Hour

Traffic load is measured in Erlangs (Erl). One Erlang is equivalent to using one trunk for one hour or the sum total usage of all trunks in a group for one hour. For example, if a trunk group between two exchanges contains three trunks, and over a twenty-four hour period it is observed that the first trunk was used for 7 hours, the second for 4 hours and the third for 2 hours, then the traffic load for the twenty-four hour period is 13 Erlangs.

The daily traffic load carried by a trunk group is not sufficient to determine the number of trunks required in a circuit switching network. The daily traffic load is the sum of periods of no traffic, (evening and early morning hours), and the peak traffic periods which occur just before noon and in the late afternoon. This peak period is used to evaluate the number of trunks required in a given group This peak period, called the "Busy Hour," is composed of four consecutive 15-minute periods in which the traffic load is the heaviest.

Probability

In a circuit switching network, the traffic offered by various subscribers to a particular trunk group is usually independent of one another with respect to time and length of message. This traffic is referred to as "random" traffic and is governed by certain laws of probability. For example, Bernoulli Law, for traffic offered by a number of subscribers, states that, (1) the probability of the arrival of a call is proportional to the number of idle subscribers, and (2) the probability that an existing call will terminate, never changes regardless of how long it has existed. These rules have lead to the formulation of tables which can be used to predict the number of trunks required in a particular group, for a Busy Hour. Table I has been extracted from these tables[1]. In this table—N is the number of required trunks, B is the Grade of Service and K is the accessibility of the trunks. If we consider a Grade of Service, B, of 1% and a K of 20, it can be seen that 40 trunks are required to carry 27.3 Erlangs during the Busy Hour. The best trunk efficiency that can be determined is 68.2%.

Grade of Service

During the Busy Hour it is not economical to provide enough trunks to allow the handling of all probable calls; therefore, a certain percentage of attempted connections to the trunk group will fail to find an idle trunk. This percentage is designated Grade of Service, B. Therefore, a B of 1% means that one in every hundred attempted seizures, of trunks in any one group, will fail to instantly find an idle trunk during the Busy Hour

From Figure 2 it can be seen that the higher the percentage of lost calls-the greater the trunk efficiency; however, B must be such as to provide an economical and satisfactory grade of service to our subscribers. A percentage that is too high will cause redialing of the failed calls, thereby, increasing the number of attempted calls during the Busy Hour. This will, in turn, be reflected in an increase in the required common control units needed to process each call. Consequently, the Grade of Service chosen for each trunk group is not only a requirement for service to subscribers, but it is also a functional requirement of the circuit switching network.

TABLE I NUMBER OF TRUNKS REQUIRED FOR A BUSY HOUR						
K 10		K 20		K _ 34		N
B 1%	B 10%	B 1%	B 10%	B - 1%	B 10%	
1.43	2 93	1.43	2 93	1 43	2 93	5
4 57	7 57	4.57	7 57	4 57	7 67	10
7 5	11.8	8 23	12 60	8.23	12 60	15
10.4	16.0	12 13	17 72	12.13	17 72	20
13.4	20 2	15.9	22 6	16 27	23.00	25
16.4	24 4	19 7	27.5	20.5	28.31	30
19.4	28 6	23 6	32 4	24.8	33 4	35
22 4	32.8	27 3	37.2	29 0	38 6	40
25 4	37.0	31 2	42 1	33.1	43 7	45
28.4	41 3	35.1	47.0	37.3	48.9	50
31.4	45 5	39 0	51 9	41 5	54.0	55
34 4	49 7	42 9	56.8	45.8	59 2	60
37 4	53.9	46.8	61 7	50 0	64 3	65
40 4	58 1	50 8	66 6	54 2	69 4	70
43.5	62 3	54.7	71 5	58 5	74 5	75
46.5	66.5	58 6	76.4	62.8	79.7	80
49.6	70 7	62 5	81 3	67 0	84.8	85
52.6	74.9	66 4	86.1	71 3	89 9	90
55 6	79 1	70 3	91 0	75 6	95 0	95
58 7	83.4	74 3	95 9	79 9	100 2	100

N = Required Number of Trunks
B = Grade of Service
K = Accessibility

Accessibility

The maximum number of trunks that are available to an individual subscriber is designated as the accessibility, to the trunk group. This limit is a function of the type of switch used in the exchange where access is being sought.

In the Western Union Telex Network, a TW39 Exchange uses a two-motion switch which has a physical trunk scanning limit of K=10. A TWM2 exchange uses a motor driven switch (EMD) having 192 output studs, which can be divided into fourteen different groups, each having varying values of K. In the TWM2 exchange, the actual value of K used depends upon the number of groups required and the relative cost of the individual trunks in each group.

For example, referring to Figure 1, let it be assumed that (1) of the 192 studs at New York, there are 40 remaining to be proportioned between the Chicago and Los Angeles trunk groups, (2) the Chicago trunk group carries a Busy Hour traffic load of 50 Erlangs, and (3) the Los Angeles trunk group carries a Busy Hour traffic load of 30 Erlangs.

If the costs of a trunk between New York and Chicago is the same as New York and Los Angeles, then it may be concluded that the studs should be proportioned according to traffic load. This however, is not the case, and referring to Table I, 30 Erlangs can be carried with a K=10, by 53 trunks and with a K=20 by 44 trunks, for a 1% Grade of Service, B. This leaves a 9-trunk difference in the New York, Los Angeles trunk group between K=10 and K=20. On the other hand, 50 Erlangs can be carried with a K=20 by 69 trunks and with a K=34 by 65 trunks. This leaves a 4-trunk difference in the New York, Chicago trunk group between K=20 and K=34. Looking at these figures and the difference in the costs of a single trunk in each group, the 40 studs are arranged to be K 20 for both Los Angeles and Chicago.

Direction of Seizure

The Telex network is made up of full duplex teleprinter trunks between exchanges that can be seized in one direction or in both directions. Since all trunks are full duplex, the only reason for one direction seizure is that less equipment and/or less expensive equipment is required. This also saves floor space and installation time. A given trunk group will then consist of incoming, two-way and out-going trunks. The porportions to be provided for these three types of trunks are the result of a very careful traffic analysis.

For example, referring to Figure 3, the traffic distribution between New York and Los Angeles consists of two almost equal peak periods. However, the direction of the traffic during each period usually flows in opposite directions because of the different time zones. The Busy Hour is the first peak period of 30 Erlangs and with a K=20 in both directions and a B=*1%*, 44 trunks are required. The first peak period consists of 25 Erlangs from New York to Los Angeles, which requires 37 trunks in that direction. The second peak period consists of 22 Erlangs from Los Angeles to New York which requires 33 trunks in that direction. These three requirements can then be met with 11 out-going trunks from New York, 26 two-way trunks and 7 incoming trunks to New York. From this example, it is evident that the proportions to be assigned in any trunk group, is not just a function of the traffic carried by the group. Rather, it is a combined consideration of the accessibility in each direction, and the traffic and time relationships between the peak periods in each direction and the Busy Hour. For example, if the peak traffic period in both directions occurred simultaneously, this period would be the Busy Hour. If the traffic carried during this period were 30 Erlangs as in the previous example, (which contains 60% two-way trunks), the number of two-way trunks would be a very small percentage of the trunk group.

Another factor in determining the percentage of two-way trunks is the size of the trunks group. As shown in Figure 1, the Busy Hour between Washington and New York carries 7 Erlangs. With an accessibility in both directions of K 34 and a B 1%, 14 trunks are required. How-

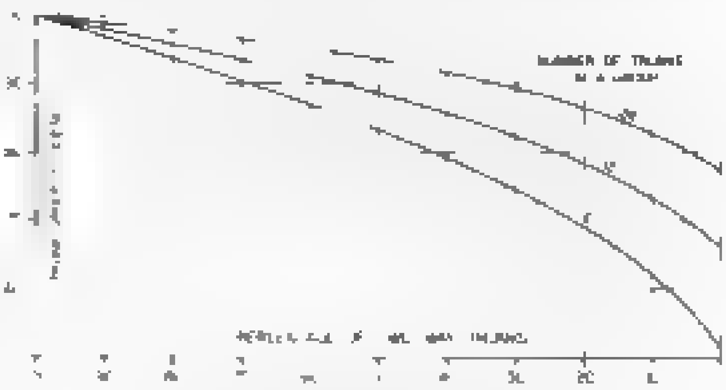

Figure 2 Trunk Group Efficiency (B 1%)

ever, in small trunk groups it is very difficult to predict or define the peak in either direction because random access is to be gained by only a small group of subscribers, and daily individual factors could affect the direction of traffic. The requirement for 14 trunks was obtained from Table I, however, this table is based on all two-way trunks and the graph shown in Figure 2 indicates that trunk efficiency decreases as the number of two-way trunks decrease, for small trunk groups. As in this example, 14 two-way trunks can actually carry 7.46 Erlangs and if it is decided to make 6 trunks two-way, then the trunk group would be operating at an efficiency of 95%. This would mean that the trunk group arrangement could carry 7.09 Erlangs instead of 7.46 Erlangs during the Busy Hour. The

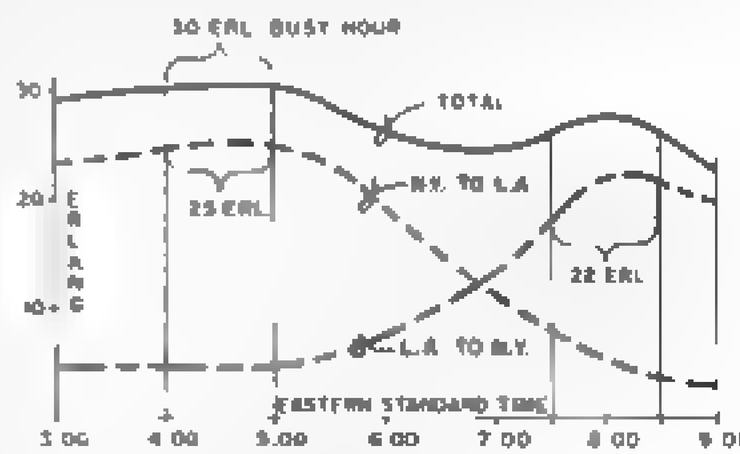

Figure 3. Distribution of Traffic New York & Los Angeles

economies, however, obtained by making only 6 trunks two-way will justify this arrangement, because the trunk group is only required to carry 7 Erlangs.

Automatic Alternate Routing

In order to obtain the maximum possible efficiency in major trunk groups in the Telex network, automatic alternate routing is provided. For example, as shown in Figure 1, 50 Erlangs of traffic during the Busy Hour between New York and Chicago would require 67 trunks for a B=1%. If however, the traffic between New York and Los Angeles and Los Angeles and Chicago is low enough to allow 8 Erlangs to be imposed on these trunk groups by alternate routing of the traffic between Chicago and New York, then only 57 trunks would be required between Chicago and New York. This arrangement results in increased trunk efficiency for all trunk groups involved.

The choice of an alternate route path and the amount of traffic that can be offered to it is materially affected by the different time zones, and communities of interest. Sometimes the choice of alternate path must be changed or the proportion of carried traffic altered. Therefore, a continuous traffic analysis must be made on the alternate routing pattern. It must be recognized that automatic alternate routing is the means of maintaining an economical and efficient trunking arrangement providing it is kept under constant observation.

High Usage and Final Trunk Group

Another application for automatic alternate routing is in the development of high usage and final trunk groups. There are two ways to increase the efficiency of a trunk group. The first is to increase its size and the second is to decrease its grade of service. For example, referring to Figure 1, the San Francisco exchange has a low traffic volume for the other exchanges. If the trunks were allocated according to traffic, with automatic alternate routing used to flatten the peak periods, then small trunk groups would be provided between San Francisco and the other exchange. Since these are small trunk groups, the trunk efficiency will be low. If on the other hand, the trunks between San Francisco and Chicago, and between San Francisco and New York are made very small with a very poor grade of service, (High Usage) the trunk group between San Francisco and Los Angeles would have to be made large (Final) to accommodate the overflow from the other two trunk groups. The trunks would now operate at a much higher efficiency. The method used to calculate the number of trunks in the high usage and final trunk groups is purely a matter of economics. A trunk should be added to the high usage group, one at a time, until the cost of providing the service per unit of traffic in the high usage trunk group is equal to or just less than the cost per unit of traffic in the final trunk group.

(Continued in January 1964 issue)

References

1 Measuring Equipment for Observation of Traffic and Quality of Service in Telephone Dial Offices—Siemens and Halske
2 Tables for the Planning and Operation of Telephone Systems Siemens and Halske

Part II of this article will appear in the January 1964 issue. This section will be devoted to the Switch Stages, another factor in Traffic Evaluation for the Western Union Telex Network.

The biographical sketch of Mr. Jockers appeared in the July 1963 issue and will appear at the end of this article.

W. L. Johnson, City Operations Supervisor — Plant Department at Miami, Florida

Test and Dispatching Circuits
–Plan 39–

International tensions and stringent communications requirements of government agencies increased the importance of test and dispatching functions

Background

In the past decade, Western Union has experienced more changes in the concept of communications than ever before. Paralleling these changes has been an ever increasing demand for a more rapid means of communication between our test rooms, in order that rapid restoration and quality performance of circuits be provided for our leased subscribers. Only a few years ago, most leased subscribers were located in or near major cities where facilities were readily available. The trend towards dispersion of operations in all industries, especially with the Armed Forces, has resulted in further demands for service to points previously considered unimportant from the standpoint of requirements for telegraph service. This may be illustrated by a review of the changes in service handling requirements and the effects they have had in influencing the design of the Plan 39 Test and Dispatching System.

Several years ago, the method of providing the coordination for service handling and dispatching functions was to establish territorial "Test and Dispatching Circuits." These circuits linked together only those offices having a need to communicate with each other. The circuits originally utilized morse keys and sounders for the exchange of information and operated on a "party line" or "way circuit" basis. The normal configurations of these circuits were such that—major offices were linked with adjacent smaller offices or test points within a confined geographical area. The testing for and isolation of troubles were normally made via physical line wires and the testing points were responsible for those sections of the circuits which were terminated or repeatered in their office. The present state of the art requires only occassional exchange of test and dispatching information between small offices within close geographical proximity. Infrequently, manual relay of the information is necessary by a larger test room or by transmission of this information via public message channels.

Lengthening of Test and Dispatching Circuits

The general lengthening of leased circuits and especially the advent of the Central Dispatching concept eventually overtaxed the existing test and dispatching network. The trend towards more complex leased services also necessitated the lengthening of test and dispatching circuits. It also became essential for test rooms, sharing a common responsibility, to have direct contact with other offices over greater and greater distances. The operational and economic limitations, even at that time, precluded the provision of direct interconnection of all test rooms in all cases.

Consideration was given to a means of providing such contact, on an "as-needed and when-required basis." With this objective in mind, a morse circuit switching system was developed which would permit, on a selective basis, a direct interconnection of any test and dispatching circuit to another which might be terminated in this system.

This type of switching system was installed and placed in operation in one of our mid-western cities. The procedure between the two offices operating the circuit switching equipment required that the originating test room:

1. Wait until the circuit was idle before attempting to call or select another office,
2. Transmit the necessary control sequence to establish a connection to the desired circuit,
3. Transmit the office call letters of the desired test room until the receiving operator acknowledges,
4. Transmit the desired information and await an acknowledgment or reply,
5. Finally, disconnect or release the circuit connection.

As with many designs in the field of communication, this system's shortcomings soon became evident after actual use. Difficulty was encountered due to the frequent failure of personnel to properly release the connection after completing transmission. The design of the system required that a disconnect sequence be initiated on the particular circuit from which the originating connection was established. Failure to observe the proper operating procedures frequently resulted in several test and dispatching circuits being tied together through the switching system. At times forty or more offices might be simultaneously connected to a common circuit. This was convenient during low traffic density periods but presented a serious handicap during the day. Another problem was the possibility of establishing a connection to the selected circuit at a time when that circuit was in use. This rendered the originating circuit useless until the selected circuit became idle and the message exchange could be completed.

Another factor which began to influence test and dispatching circuit operation during this era was the increasing scarcity of competent morse telegraphers. To adequately train technicians in what was becoming a "lost art" was both time consuming and expensive. Futhermore, the rapid expansion and increasing complexities of leased circuits plus the demands for more rapid handling of reported malfunctions on leased systems placed greater emphasis on more rapid means of handling communications between test rooms.

Modernization of Test and Dispatching Complex

The next step was modernizing the Test and Dispatching complex and the conversion of these circuits to teleprinter operation. A simple selector was devised to produce an audible and visual alarm in the test room receiving the message. Two previous problems were immediately alleviated by using teleprinter operation

1. It was no longer necessary to instruct technicians in morse telegraphy, and
2. Circuit time was no longer consumed in repeatedly calling for a receiving operator at another test room. A message had only to be preceded by the proper selection of characters of the destined office. The exchange of information between these two offices can be transmitted at the maximum speed of the operator and the equipment.

The circuit switching equipment was abandoned because of the delays experienced due to test wires being tied together and improper disconnect procedures. Teleprinter operators were assigned at the switching center to relay all inter-city messages.

Since this double-handling of messages was not conducive to maximum efficiency, a study was made to determine its shortcomings. A new system and a modern dispatching center was designed to meet not only the present demands but also most future requirements.

As a result of this study many important factors were considered:

1. *Site selection*—such factors as size of community, housing, continuity of power, access to other communications mediums, safety from man-caused destruction, prevailing winds, etc. were carefully weighed.
2. *Access*—to other cities having principle testrooms and test and dispatching circuits.
3. *Modern switching center* — having maximum efficiency of terminated circuits, a system having flexibility, reliability and ability to expand sophisticated operating routines.

A fully automatic system was designed to meet these requirements — Plan 39 Switching System[2]

Plan 39 Switching System

The Plan 39 switching center equipment was built, constructed, and tested in Western Union's Chattanooga Works, prior to installing it in the new location for the Central Dispatching Bureau. The system was subjected to all types of simulated failures, misrouting, deviations from prescribed routines, simulated equipment malfunctions, partial power failures, etc

Minor changes were made in the design of Plan 39 during these tests so that it would not only meet present day requirements but also provide for a 10-year expansion.

Plan 39 Circuits

The circuits terminated in Plan 39 are diversified and triangulated. In the present circuit configuration, some test rooms have several access routes to the switching complex. Plan 39 has three outlets to key cities, selected because of their diversified access to alternate communications mediums. Choice of these locations was determined by availability of microwave systems, underground cable and diversified land lines

Circuit Dispatcher

The function of the circuit dispatcher is greatly enhanced in the Plan 39 Switching System. The dispatchers have immediate access to all test rooms; they have copies of all messages and trouble reports. The continuous observation of this array of circuits helps to pinpoint major failures before the dispatchers can be notified via test room reports. Through the advance correlation of this information, major test rooms are notified as to the location and magnitude of these failures. The necessity of tracing troubles individually has been eliminated. Several minutes advance time may be used toward service restoration which might be otherwise lost through notifying the circuit dispatcher

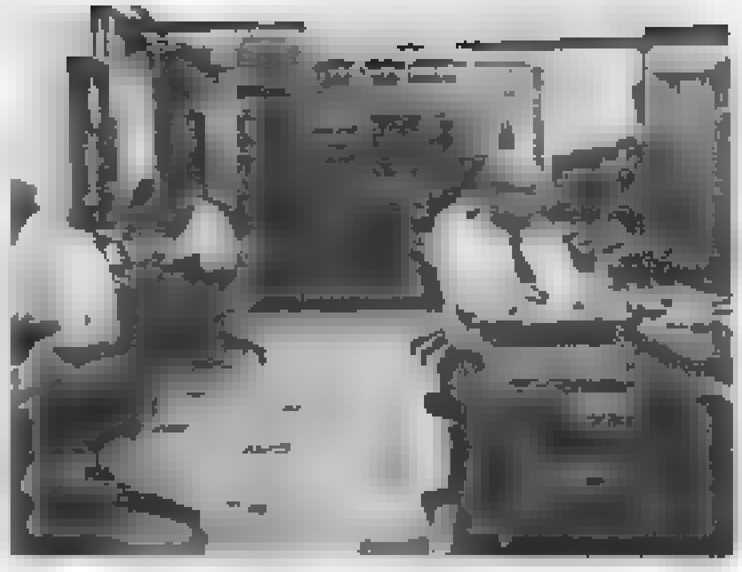

Figure 1 Dispatchers with Patching Board and Printers

Flexibility of the System

Failure on a facility lead or the loss of one or more areas within the country has little effect on the continuity and flow of traffic on the test and dispatching circuits. The configuration and routing of circuits terminated in the Switching Center is such that a 50 percent loss of these circuits would not incapacitate the system It ensures the protection of vital military circuits essential to our national defense.

Failure of a Test and Dispatching circuit activates a visual and audible alarm in the switching aisle. Operators and dispatchers can recognize the most probable location and severity of a multiple failure For example, a power failure in one of the major test rooms would cause every test and dispatcher circuit in that office to fail A quick observation of the alarm panel shows which circuits failed and an examination of the circuit layouts would show the city or area common to the "failed" circuits. A message flashed promptly to all test rooms gives the apparent location of the failure

The Dispatcher's operators have a certain routine to follow in event of such failure. Figure 1 shows the dispatchers with patching board and directly connected printers. Switching control positions are shown in Figure 2. They are used to redirect the flow of traffic in the event of failures. Protection of test and dispatching traffic is handled by means of alternate routing and switching. All available means are utilized during a crisis to minimize delays, effect restoration and keep all test rooms alerted as to the status

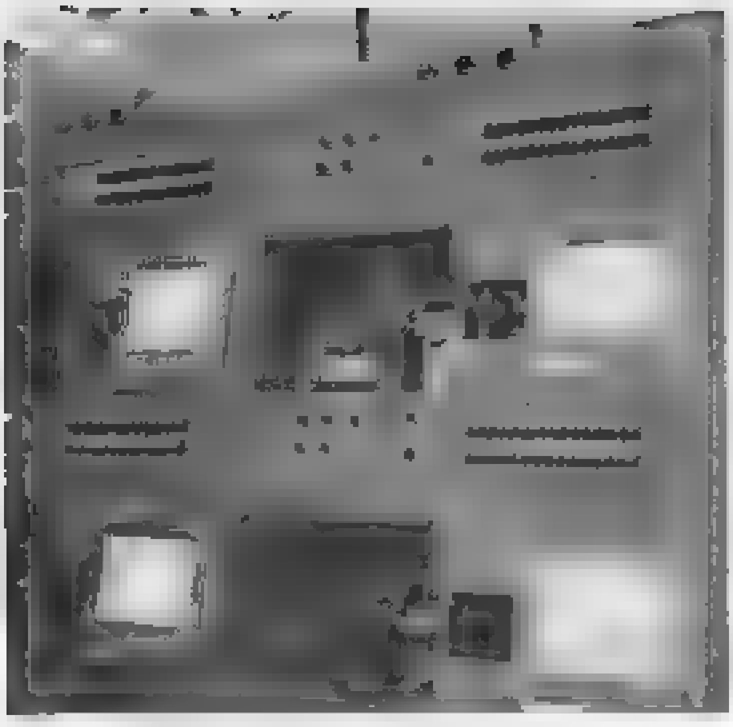

Figure 2. Switching Control Positions

of circuits and prospects of recovery.

Precautionary measures are taken in the Central Dispatching Bureau to protect test and dispatching traffic in event of total or partial failure of the system. A six months supply of all spare parts and 10 percent of all major components are kept on hand. Two trained technicians are assigned to insure and protect the continuity of message flow.

Portable System

The system was designed and installed to permit relocation if a national emergency necessitates it. All switching cabinets are interconnected by means of flexible cable and plug-in connectors so that it is possible to unplug each unit and completely transport the equipment and re-establish the system at another location.

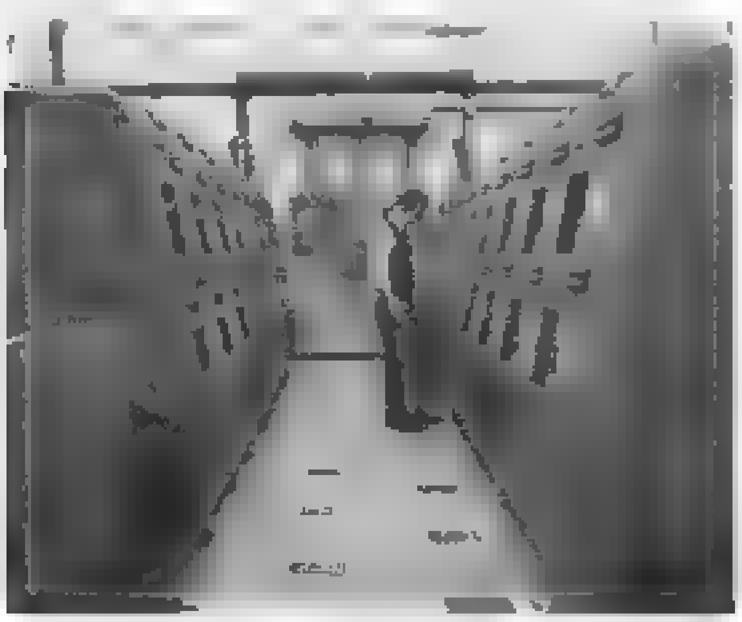

Figure 3. Switching Aisle—Plan 39

Emergency Power

Emergency power, provided in the Central Dispatching Bureau, operates at less than 25 percent of its rated continuous load capacity. The power unit is a continuity preserving source of supply. When the outside power drops below a predetermined voltage, the unit will immediately assume the full load automatically and without interruption to the switching system. The power unit is tested weekly under full load. Fuel tanks are maintained full—with a supply of fuel for at least five days operation under full load.

Training Program

Prior to activation of the Plan 39 Switching System an intense training program to acquaint the field with the operating procedures for this system was established. The full potential of the added features of this system could not be realized without adherence to the proper message format. Delays due to improper message format were mitigated by pre-terminating all test and dispatching circuits, which were to be included in Plan 39 system, in monitoring printers at the Switching Center. These monitors were observed by supervisory personnel—and any deviation from prescribed routines by an office or test room was immediately reported to the office with an explanation. The explanation of these deviations included the technical problems inherent in the system. While this was a departure from normal reporting practice, it was found that technical explanations were more effective in obtaining correction of non-routine operating practices.

The close supervision and cooperation of our field forces eventually resulted in almost 100 percent compliance with the proper operating routines, and necessitated a minimum of supervision in the switching aisles, as shown in Figure 3. Operators and supervisors now have more time for observing all incoming circuits so that maximum operational efficiency is maintained. Operators have instructions to protect a message and promptly switch it to the office for which it is intended, corrections or remarks to the originating test room are secondary.

Potential of Plan 39

The versatility of the Plan 39 Switching System makes it possible to keep abreast of the ever increasing demands for more rapid exchange of test and dispatching information.

Plan 39 is operating at considerably less than its message handling capacity. When required, this capacity may be utilized by increasing the operating speed of the circuits terminated in the system. Full duplex operation can increase the present capacity by 50 percent. The system also lends itself to satellite switching from small exchanges.

Future applications for Plan 39 are constantly being considered. Changes in avoidance routings are made as conditions require.

Actual restoration of circuits where major facilities have been lost supports the planning and success of the Test and Dispatching circuit complex. Western Union has established a means of protecting the national interests with its ability to restore communications effectively through the Plan 39 Switching System.

Mr. W. L. Johnson, formerly a General Operations Supervisor in the Plant and Engineering Department is now City Operations Supervisor, at Miami, Fla. While at Headquarters he was basically concerned with the performance and protection of leased wire circuits and the solution of problems associated with Private Wire Service. He had wide experience in field and test rooms practices.

Mr. Johnson joined Western Union in 1953 as an Apprentice Technician. Later he was assigned as an Operations Supervisor in the Atlanta Area office.

He received his technical education at William and Mary College and also an electronic technician school. He spent a two year tour of duty in the Navy where he received an honorable discharge.

* * * * *

Editorial Note. The Theory and Design of Automatic Switching System—Plan 39 was described in the July 1953 issue of the Western Union TECHNICAL REVIEW.

Switching System Devices
Solid State Devices

Firth, F R. and O'Sullivan, T. J
The Solid State Remote Control Unit and Polar Adapter

Western Union TECHNICAL REVIEW, Vol 17 No 4 (Oct 1963) pp 134 to 139

The remote control unit (RCU) is an integral part of outstation equipment in the Western Union Telex Network The Solid-State RCU and Polar Adapter described in this article was designed for greater reliability by using semi-conductors rather than relay This article describes the equipment, its operation and its advantages over the other type of RCUs.

Switching Systems (Automatic)
"Store and Forward" Switching

Codd, B E.: Switching System—Plan 56-B

Western Union TECHNICAL REVIEW, Vol 17 No. 4 (Oct, 1963) pp 140 to 147

Switching System Plan 56-B is a modification of Plan 56-A, a private telegraph communication system originally designed for brokerage firms. Plan 56-B meets present day requirements for 100 wpm operating speed. This article describes the equipment, the operation of the system and message format. The expansion capabilities of the system allow a patron to add to it on a "building block" basis for future requirements.

Switching Systems
Announcements

Paul, G. S.: Communications of the Future

Western Union TECHNICAL REVIEW, Vol 17, No 4 (Oct 1963) pp 149

This is a message from the Vice President of the Operating and Marketing Department pointing up the broad connotation of the term "switching systems" and the effects to be noted in the Communication systems of the Future as reported in the Western Union TECHNICAL REVIEW.

Switching Systems
AUTODIN
Technical Control

Falknor, F B
AUTODIN Switching System—Technical Control Facility

Western Union TECHNICAL REVIEW, Vol 17 No. 4 (Oct, 1963) pp 150 to 155

This is the first of a series of articles on AUTODIN This article describes the layout of the technical control facility and a description of the Monitor Console and Crypto Console designed by Western Union and provided to the United States Air Force

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Announcements
Awards

1963 d'Humy Medalist—B. L. Kline

Western Union TECHNICAL REVIEW, Vol. 17, No. 4 (Oct. 1963)
pp 156 to 157

This is an announcement of the presentation of the 1963 d'Humy Award to Mr. B. L. Kline "for his development of new concepts of electrosensitive recording phenomena, and for the embodiment of the results of his research in facsimile recording papers."

Telex
Traffic Evaluation Technique
Circuit Switching

Jockers, K. M.:
Traffic Evaluation—Part I in the Western Union Telex Network

Western Union TECHNICAL REVIEW, Vol. 17, No. 4 (Oct. 1963)
pp 158 to 162

Special evaluation equipment and techniques are used to report traffic patterns so that exchanges can be planned to meet subscriber requirements. In the Western Union Telex Network, thousands of subscribers are connected through various combinations of trunk sections and switching stages.

Part I of this article is concerned with the Trunk Analysis.

Part II, on switch stages and common equipment, will appear in the January 1964 issue of the Western Union TECHNICAL REVIEW.

Circuit Switching
Test and Dispatching Circuits
Switching Systems

Johnson, W. L.: Test and Dispatching Circuits—Plan 39

Western Union TECHNICAL REVIEW, Vol. 17, No. 4 (Oct. 1963)
pp 163 to 167

This article describes the need for, and the provision of, an automatic switching system designed specifically for the handling of test and dispatching circuit traffic at the Western Union Central Dispatching Bureau. Operational features and their advantages are covered.

Two-Year Index

Western Union TECHNICAL REVIEW, Vol. 17, No. 4 (Oct. 1963)
pp 170 to 171

This two-year index lists all the articles printed in the Western Union TECHNICAL REVIEW in the years 1962 and 1963.

This list is composed of a subject index and an author index.

TWO YEAR INDEX

JANUARY 1961 — OCTOBER 1963 (Volumes 16 and 17)

SUBJECT INDEX

Computer Techniques

Data Processing

Display Systems

Microwave

Switching Systems

Transmission

Miscellaneous

INDEX (Continued)

AUTHOR INDEX

A YEAR WELL DONE—1963

President Walter P. Marshall

Awards the Medal of the Year

On Sept. 25, 1963, President Marshall (right) awarded the 1963 d'Humy Medal to B. L. Kline (center) Plant and Engineering Department for his significant contributions to the telegraph art. Mr. C. M. Brown, left, Vice President of Plant and Engineering was Master of Ceremonies at the Award Presentation. Mr. Brown reviewed the history of the d'Humy Award and introduced the previous award medalists. Before turning over the ceremonies to Mr. Marshall, Mr. Brown paid special tribute to the Award Committee for its selection of the medalist this year. The Award Committee was composed of D. F. Hazen, C. S. Lawton, G. G. Light, W. J. Lloyd, M. R. Marsh, G. P. Oslin, K. H. MacGibbon, Program Chairman and G. A. Randall, Chairman.

The portrait in the background is that of Newcomb Carlton who was President of the Western Union Telegraph Company from 1914 to 1933.